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AN

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AN INTRODUCTION TO CONCHOLOGY;

OR, ELEMENTS OF

THE NATURAL HISTORY OF

MOLLUSCOUS ANIMALS.

BY

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LONDON:
JOHN VAN VOORST, PATERNOSTER ROW.

M.D.CCCL.

LONDON:
Printed by S & J. BENTLEY and HENRY FLEY,
Bangor House, Shoe Lane.

TO

JOHN EDWARD GRAY, Esq., F.R.S.,

ETC.

KEEPER OF THE ZOOLOGICAL COLLECTIONS IN THE BRITISH MUSEUM :

WHOSE VALUED FRIENDSHIP AND LEARNED GUIDANCE

THE AUTHOR

HAS ENJOYED FOR MANY YEARS,

AND

WHOSE CONTRIBUTIONS FORM THE MOST VALUABLE PORTION OF IT,

THIS WORK

Is gratefully dedicated.

PREFACE.

This Work was suggested by the perusal of Kirby and Spence's "Introduction to Entomology," and it is based on some letters which I contributed to Loudon's "Magazine of Natural History," between the years 1829 and 1834. This acknowledgment is necessary, for as the letters were anonymous, a reader might perchance be found to conclude that I had been guilty of plagiarism on rather an extensive scale.

My object is to present the Conchologist with a view of the economical, physiological, and systematical Relations of Molluscous Animals to each other, and to other created beings. I am not aware of any other Introduction, in the English language, in which this has been attempted; and therefore my little ambition to occupy the vacant niche in the literature of a favourite department of natural science may be the more excused. I am very sensible that the Essay has not been satisfactorily accomplished; and it would have been still less so, but for the liberal permission given to me by Mr. Gray to avail myself of some of his valuable writings, the republication of which, in a more accessible form, cannot but be acceptable to the Conchologist.

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AN

INTRODUCTION TO CONCHOLOGY.

THERE are not many inducements to become a Conchologist: his pursuit has always been deemed one of an inferior character, and the fame of none of its masters has ever extended beyond the narrow pale of his fellow co-operators, excepting when, in one or two instances, the witty pen of the satirist has momentarily fixed the public eye upon this obscure object of its ridicule. Unless, therefore, you are content to forego all chance of literary fame, and to rest satisfied with a very moderate share of scientific reputation, you had better at once leave this private path, and betake yourself to a higher and more frequented road: there are many, not few of them less pleasant and less useful to the traveller, which lead to the gratification of a higher vanity. But should you, unambitious, still feel disposed to follow the bent of your taste, satisfied that, in these matters,

> "He chooses best, whose labour entertains
> His vacant fancy most," *

I shall willingly assist you towards its gratification, because I am fully convinced that there is as much pleasure, and as much profit, to be found in the cultivation of this department of natural history as in any other. You are not going to follow it out as the chief object of your life,—that were to do what I could not commend,—but as a recreation to relax and refresh the wearied mind, as a resort to fall back upon in those hours of idleness which will overtake the busiest of us

* "It is a very useless inquiry—what kind of knowledge, or what line of occupation is best?—all are good, and, in a complex system of society, all are needful. The community will best be served, if each do strenuously what he can do best, without troubling himself about the comparative worth or dignity of his vocation."—*Hartley Coleridge.*

all, and to which you are more than ordinarily exposed in a "haunt remote from public life." A man who is anxious that these hours should not be wasted in the indulgence of a lazy, listless humour,* or in diversions where mind and feeling have no place, will do well to provide against the evil by some occupation in harmony with his natural disposition; and although I have no wish to overrate the advantages of seeking that occupation in the study of the works of creation, yet to those whose minds are so framed that they take pleasure in their contemplation, there is nothing to forbid the indulgence of their taste, and much to say in favour of it. I need not dwell on these advantages, since they are common to Conchology with other branches of natural history; and they have been so fully argued by many authors of late years, and more especially by Herschell, that their validity is generally acknowledged. Now, indeed, when man's varied pursuits are fairly enough estimated, natural history probably numbers among the sciences more votaries than any other; so that no sooner shall you have entered on the field of your choice, than you will find yourself surrounded and encouraged by a galaxy of congenial spirits engaged in the same or congenerous studies; and, so far from having to bear up against the ridicule which might, at no late period, have been your portion, as it was that of some of our predecessors, you will find, not certainly a strong tide of popular favour to carry you along, but a tacit acquiescence in the becomingness of the study, and a forbearance, at least, from all censure which might fray even the most sensitive. Should inclination or leisure therefore serve you no further than to attain the ability to arrange and name your collection after some approved system, you will be thought even then rationally and worthily employed, and, in my opinion, justly so. To know the name, in reference at least to many objects of nature, is to know the thing: before this could have been ascertained, the principles on which the system is founded must have been mastered, and the characters of the object whose name is sought after must have been examined with the most scrupulous care; all

* "If men from their youth were weaned from that sauntering humour, wherein some, out of custom, let a good part of their lives run uselessly away, without either business or recreation, they would find time enough to acquire dexterity and skill in hundreds of things, which, though remote from their proper callings, would not at all interfere with them. And therefore, I think, for this, as well as other reasons before-mentioned, a lazy, listless humour, that idly dreams away the days, is of all others the least to be indulged or permitted in young people. It is the proper state of one sick and out of order in his health, and is tolerable in no body else of what age or condition soever."—*Locke.*

its external structure in fact made familiar by the process, and, if the system was worth anything, most of the leading habits impressed upon the memory. The knowledge thus acquired will be variously estimated, but still it has not been gained without an exertion of the reasoning faculties which many who deem it trifling are incapable of making,—an exertion which repays itself in its tendency to strengthen habits of attention, and check the discursive levity natural to the untutored mind. This beneficial effect of systematic natural history has been properly much insisted on by several recent authors; and if, which I grant to be the case, the exercise is less effective for this purpose than the study of mathematics,* yet to many who cannot overcome a distaste to these, or surmount their difficulties, it comes recommended by its comparative facility; and there are here some concomitant allurements to induce us to tread with a more constant purpose, the dry paths of analysis: for while the imagination is kindled by the task, and the mind kept in active attention, the eye is pleased by the beauty of the objects under examination, the taste gratified and improved by the contemplation of new structures, and a rational curiosity indulged when it seeks out the purposes for which all is designed. It will then "be always an amusement, gratifying, innocent, and instructive, to collect the shells we meet in our walks on the sea-beach and elsewhere; to find out, by comparing them with their descriptive catalogues, to what genus, and to what species of that genus, they belong, and to arrange them accordingly. This habit will introduce us to one portion of the great Temple of created nature."†

But the importance of Conchology, studied even in this limited manner, has of late years received ample illustration. The geologist is compelled ever and anon to descend from his high speculations relative to the construction of this globe to solicit material and support from the matter-of-fact conchologist, whom he calls upon to determine the character and names of the various shells which are found by millions in the rock, to tell him of their probable habits,—whether denizens of a former sea or of fresh-water lakes,—to tell him whether they

* Milne-Edwards, whose opinion is entitled to much attention, does not admit this: on the contrary, he says,—"et, plus qu'aucune autre science, l'histoire naturelle exerce notre intelligence dans la méthode, partie de la logique sans lequelle toute investigation est laborieuse et toute exposition obscure."—*Elémens de Zoologie*, p. 5. Paris, 1840.

† Turner, Sac. History i. 302.—On the advantages of the study of Natural History, I would especially draw attention to a pamphlet, entitled, "Natural History as a Branch of General Education," by my friend Robert Patterson, of Belfast. 1840.

have disappeared from among existing races, or whether they still find their living representatives; and refreshed with this information he again ventures to chronicle, with a bolder hand, the catastrophes and revolutions which the world has suffered in its evolution from chaos to its present fixed and ordered magnificence. The Conchologist is an indispensable ally to the geologist, to satisfy whose demands he has entered on inquiries of the nicest nature, requiring a delicacy of observation, and a tact in detecting differences amid resemblances, which long and diligent exertion can only give; and a knowledge of the habits of living shell-fish which has been the result either of much patient observation, or the conclusions of a strict logic. So that if Conchology can be followed as a pleasant relaxation from other duties, your experience will ere long satisfy you how wrongfully it has been considered by many as such only: the obstacles to its mastery in all its bearings are indeed sufficient to stimulate your perseverance to overcome them, and more than sufficient to scare away from the pursuit most of those who flatter themselves they act a courteous part when they complacently allow that you are at least harmlessly engaged! *

For the present, however, you and I will study Conchology with the view neither of forming a cabinet of shells, nor of becoming auxiliaries to the geologist, but as an important branch of natural history which cannot be neglected by any one who is desirous to obtain a correct knowledge of the animal economy,† of the structure and habits of animals in general, and of their mutual dependencies and relations. To the naturalist who studies in this spirit, no one class, however apparently insignificant, is perhaps less worthy his attention

* Deshayes has applied his knowledge of Conchology to determine the temperature of Europe during the tertiary periods; and Biology may draw from Conchology numerous materials.—Charlesworth's Mag. Nat. Hist. i. 9—16.

† "Neither will it be requisite for me to enlarge upon the advantage of extending your views to the examination of the animal kingdom in general, with reference to the physiology of man: for it is obvious that our knowledge of the functions and structure of the human body would be very imperfect without a comparative investigation of those of animals. Indeed all the important discoveries of modern times, with regard to the human economy, have been derived from observations made on the lower animals. Among the many examples of the truth of this proposition, we may cite the discovery of the circulation of the blood, by which the name of Harvey has been immortalized; that of the lacteals by Asellius; and that of the thoracic ducts by Pecquet; all of which were obtained from this source. The works of Haller bear ample testimony to the advantage which has resulted to physiology from the cultivation of this wide field of inquiry."—Dr. Roget, Lect. on Hum. and Com. Physiology, p. 97.

than another; certainly the mollusca are not the least so, for their numbers in species and individuals are proof of a proportionate influence in the animal kingdom;* their complexity of organisation claims for them a considerable rank in its roll; and the many notable peculiarities of structure in their nervous system, in their circulatory apparatus, in their secretions, and in their generative system, recommend them in a lively manner to the comparative anatomist and physiologist. It was in such investigations that Cuvier laid the foundation of his immortal fame; and the results of them he has recorded in a work which has become one of the Conchologist's most valued classics. I mention it now as a proof that you have engaged in no worthless or trifling pursuit, and a stronger one I cannot give; for, after Cuvier had attained a reputation surpassed by no cotemporary philosopher, he thus speaks of his first studies, and thus invites you to their participation: if, says he, in allusion to the work just mentioned, "these *Memoires* have no other effect than to direct the attention of others to the singular peculiarities which the history of molluscous animals offers to their notice, I shall have done well, and be repaid for the toil of my task!" We honour ourselves in accepting the invitation of such a man.

It was Cuvier who, first of all, gathered together these animals, hitherto scattered among many classes, and assigned to the group or subkingdom the denomination of MOLLUSCA, a term in previous use, but which had been very vaguely defined and applied. They are so named because they have soft fleshy bodies, devoid of bones. They are readily distinguished from all above them in the animal kingdom by the want of an interior skeleton, and by the colourless condition of their blood; and from insects and worms they are distinguished with equal facility, for the body of the Mollusca is never divided, like that of insects and worms, into rings, nor invested with a hard crust or skin, fitted like a coat of mail, to the junctures, nor even furnished with jointed limbs and organs of progression. On the contrary, the Mollusca have a soft undivided body, covered with an irritable mucous skin, moistened with a viscous liquor, which exudes from it: this skin, in very many instances, is ample enough to be formed into membranes and fleshy folds, and hence assumes somewhat

* "The number of Mollusks already in collections, probably reaches 8,000 or 10,000. There are collections of marine shells, bivalve and univalve, which amount to 5,000 or 6,000; and collections of land and fluviatile shells, which count as many as 2,000. The total number of Mollusks would therefore probably exceed 15,000 species."—Agassiz and Gould's Princ. of Zoology, i. p. 3. 1848.

the appearance of a mantle or cloak, a name borrowed by naturalists to designate this part. When the animal is naked, the cloak is thick and mucous; but when covered with a shell, as it mostly is, the transparency and tenuity of the covered parts prove how much it has felt the influence of a protecting medium.

But this character of indivisibleness of the body and deficiency of members will not distinguish the Mollusca from all avertebrate animals; for many of the Radiata, and all the Zoophytes are in the same condition. From the former, however, they may be known by the disposition of their organs, which do not tend to or radiate from a centre, by the mucous nature of their skin, for in the Radiata it is either a calcareous or leathery coat, or a thin pellucid pellicle, and their locomotive organs are in the form of tubular processes or papillæ, or long pendant membranes; while the Mollusca move on a flattened disk, or by a tongue-like solid foot, or swim by means of certain folds of their mantle. They are with greater difficulty to be distinguished from Polypes. With most of them indeed there is no uncertainty: their superior size, the existence of a shell, their peculiar form and locomotive powers are all obvious distinctive characters; but when you come to investigate the subject with more minute care, you will find it difficult to tell a compound tunicated Mollusk from one of the more highly organized Polypes: and modern discovery seems likely to prove that the lines of demarcation are ideal. As it is, I know of no distinctions but which are anatomical. All Mollusca have a heart and blood-vessels, all have traces of a nervous system, and all have an internal respiratory apparatus; but Polypes have no heart and no vessels, no nerves nor ganglions, and the respiration is external,—the tentacula which encircle the outer margin of the mouth being the organs of that primary function.

The Mollusca form a subkingdom, the natives of which may be divided into two great sections: those which have a head, more or less distinctly formed, we name the *cephalous*, and the *acephalous* are of course those which are deprived of this part, and in which the mouth lies hidden in the bottom of the mantle.

Among the former, the Cephalopods occupy the first rank. They derive their name from the circumstance of their feet being placed upon the head, and in a circle round the mouth, a character which suffices of itself to distinguish them from all others. They are represented by the Cuttle-fish; and it is presumed that all shells formed like the shell of the Nautilus, are tenanted by animals of similar conformation. Their

feet are unjointed, and furnished along their inner aspects with a series of cups, which the animal can affix to foreign bodies, on the principle of a cupping-glass.

The PTEROPODS are free Mollusca, which have no feet to arrest their prey, nor foot to creep on; but they float constantly in the water, sustained and moved by means of a pair of fins, which are placed at the sides of the mouth in some of them, and of the neck in others. With their habit of floating near the surface, you will naturally conjecture that a heavy shell is incompatible, and you are right: the shell is always light, thin, and transparent; and even its form is so anomalous, that a Conchologist soon learns to distinguish them, although he may never have seen the living inhabitant.

But the great majority of the cephalous Mollusca creep on the belly, by means of a flat muscular disk, and hence they are named GASTEROPODS. The slug, the snail, the whelk, periwinkle, and limpet, are familiar examples of this class. On tropical shores its representatives are found in the cowries, cones, and volutes, the pride of all collectors, and in the rosy cheeked conchs or spinous rock-shells brought home from foreign climes .by the sailor-boy, to become the favourite ornament of the chimney-piece of our English parlours.

The acephalous Mollusca form two classes: one the bivalvular or CONCHIFERA, known by its shell, which is always formed of two pieces or valves, shutting against each other and enclosing the animal, as the oyster and cockle; the other class affords no familiar illustrations, for it is composed of creatures which are neglected and unnamed by the vulgar. They have been called TUNICATED Mollusca, for they are in no instance covered with a shell, but merely with a leathery or soft carnous tunic, in which there are two circular apertures, one for the admission of water and food into the interior, and one by which the effete and excrementitious parts are expelled. Cuvier enumerates two other classes of this section: the BRACHIOPODS, which are properly a subclass of conchiferous Mollusca, furnished with a pair of fleshy ciliated arms, capable of being protruded beyond the circumference of the shell, and made subservient apparently to respiration as well as the attraction of food: the other class is the CIRRHOPODS, in which the famous Barnacles and Acorn-shells are included; but as recent discoveries have proved that these belong properly to annulose or crustaceous animals, we must exclude them from our Molluscan assemblage.

Such then are the names and distinctions of the primary tribes of the class of animals whose history I have undertaken to give you, and which it seemed necessary you should know

before we could proceed further. I enter on the task willingly, and owe you indeed thanks for having imposed it on me, since it is very congenial to my taste, and will supply pleasant occupation for hours, which might otherwise have been wasted in idleness or ennui. If I succeed in communicating to you a portion of my own enthusiasm, I feel assured you will not repent having been brought into this way of study. Several years have passed away since I entered upon it, and each succeeding year the path has become pleasanter and more thickly strewed with flowers; and your experience, trust me, will be correspondent.* The alphabet undoubtedly must be first acquired, and alphabets are irksome; what others have done must be learned, and in this we have little other enjoyment than what every one is conscious of while adding to his stores of knowledge; but when you are thus prepared to enter into all the perplexities of synonymes, and all the niceties of systematical arrangement, to balance the *pros* and *cons*, and try your skill in untying Gordian knots which others, you fondly deem, have vainly tried to untie before, then begins your real interest and zest: and leaving even these small points behind, you may go onwards to trace the paths which Lister and Cuvier loved to tread—to examine the living animals in their haunts—unravel, with the knife and the glass, the perplexed structure which supports their life and regulates their functions and their habits.

> "By swift degrees the love of nature works,
> And warms the bosom,"—

Enthusiasm grows apace, and now, strong enough, you are urged to explore untrodden paths where, amidst the new structures and unveiled proofs of your Creator's wisdom which disclose themselves at every step, you lose yourself in rapture and praise!

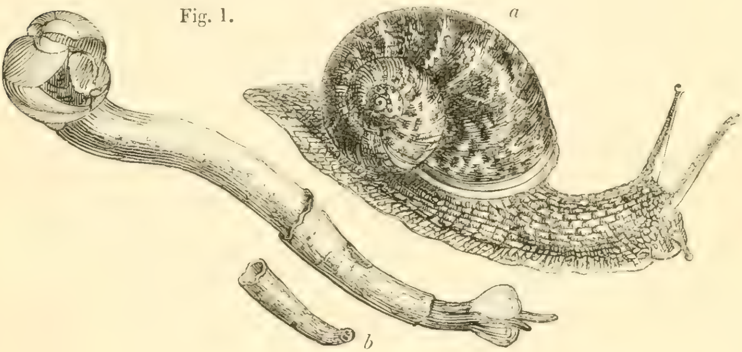
* "Scandenti circa ima labor est: cæterum quantum processeris, mollietur clivus, et lætius solum. Et, si hæc quoque jam lenius supina perseverantibus studiis evaseris, inde fructus illaborati, offerunt sese, et omnia sponte proveniunt: quæ tamen, quotidie nisi decerpantur, arescunt."—Quinctilian, Instit. Orat. xii. 10.

LETTER II.

THE MOLLUSCA CONSIDERED AS HURTFUL ANIMALS.

It is natural to conclude, that if the snail and oyster fairly represent the class, man can have nothing to fear from animals of such limited faculties and proverbial hebetude; and while I willingly admit that they have no claim to any bad pre-eminence among his enemies, there are still some noxious species of celebrity among them, whose evil works may occupy our attention in this letter.

Fig. 1.



Of the marine tribes, the Shipworm (Fig. 1, *b*), is the only one which has attracted much attention; but the devastation this worm-like Mollusk commits, is sufficiently extensive to have earned for it a hateful notoriety, and justifies the strong language of Linnæus, when he styles it the "calamitas navium." It has been gifted with the power of boring into wood, and while following this instinct, and working out the plans of Providence in removing wrecks and obstructions which have been carried to the ocean, ships, piers, and bulwarks are equally obnoxious to it, and by drilling them in every direction, they soon become unable to resist the violence of the waves, and are washed away. The amount of the damage which the Teredo thus inflicts on marine property is difficult to calculate; that it is very considerable is proved by the complaints made of the mollusk in almost all

seas, and the numerous expensive methods which have been adopted to avert its attacks. There is in the Indian seas, says an anonymous traveller, "a kind of small worms that fasten themselves to the timber of the ships, and so pierce them, that they take water everywhere; or, if they do not altogether pierce them through, they so weaken the wood, that it is almost impossible to repair them. To preserve the ships," he continues, "some have employed deal, hair, and lime, &c. and therewith lined their ships; but, besides that this does not altogether affright the worms, it retards much the ship's course. The Portugals scorch their ships, insomuch that in the quick works there is made a coaly crust of about an inch thick. But as this is dangerous, it happening not seldom, that the whole vessel is burnt; so the reason why worms eat not thorow Portugal ships is conceived to be the exceeding hardness of the timber employed by them."* In the West the Teredo is equally active, as the observations of Sir Hans Sloane and Dr. Browne prove.† Our early navigators were frequently thwarted or controlled in their bold enterprises by their ships being rendered, by its means, unsafe or useless; and as our commerce enlarged, the evil was so severely felt that it led to the plan of sheathing the bottoms of ships with lead and copper, for which important discovery an Act of Parliament was passed to secure to Sir Philip Howard and Major Watson the sole use and profits which might accrue from it. From the tropical seas the Teredines were commonly believed to have been introduced into those of Europe, somewhat less than two centuries ago; but as there is more than sufficient evidence to prove that certain species are truly indigenous,‡ the hope vanishes of ever seeing them extirpated by a winter severer than usual, or by a continued temperature inimical to their constitution, as might have happened had they been colonists from the tropics; for the Teredo almost always resides near the surface, and often in situations which are left dry during the ebb, where it is

* Phil. Trans. an. 1666, p. 190.

† Hist. of Jamaica, p. 395. Dr. Browne has erroneously figured a species of Nereis for the "ship-worm."

‡ In some parts of the London clay, branches and stems of trees, penetrated by the Teredo navalis are found."—*Bakewell's Geology*, p. 325. At Belfast, it has been found buried in blue clay twelve feet beneath the surface, where it must have been deposited centuries before Europe enjoyed any commerce with either the East or West.—*Edin. New Phil. Journ.* xviii. 126. For correct descriptions and figures of our native species, the reader is referred to the "British Mollusca" of Forbes and Hanley, i. p. 66—89. The authors have given an interesting sketch of the Teredo's misdeeds as an introduction to their account of the species.

necessarily subjected to the atmospherical changes. Its destructive operations in European seas are not therefore weakened by a less genial locality. In the years 1731 and 1732, the United Provinces were under a dreadful alarm;* for it was discovered that these Mollusks had made such depredations on the piles which support the banks of Zealand and Friesland, as to threaten them with total destruction, and to reclaim from man what he had with unexampled labour wrested from the ocean. A few years after they fortunately abandoned the dikes; but fearful of the return of an enemy more powerful than the Grand Turk even, who boasted that he would exterminate them with a host armed with spades and shovels, the Dutch offered a reward of value to any one who should discover a remedy to ward off their attacks, and ointments, varnishes, and poisonous liquors were recommended by the hundreds. The exact amount of the damage done at this visitation, which Sellius, unable to discover any natural cause for it, says was sent by the Deity to punish the growing pride of the Hollanders, I have not been able to ascertain. Writers in general speak of it as "very great;" and Dr. Job Baster mentions the Teredo as an animal "which has done so many millions damage to these countries."†—In our own country it has done, and continues to do, extensive mischief. The soundest and hardest oak cannot resist these noxious creatures; but, in the course of four or five years, they will so drill it as to render its removal necessary, as has repeatedly happened in the dock-yard of Plymouth. To preserve the timbers used there, and exposed to them, the plan now adopted is to cover the parts under water with short broad-headed nails, which, in salt water, soon invests the whole with a strong coating of rust impenetrable by their augers.‡ The plan appears to have proved effectual, for, in the harbours of Plymouth and Falmouth, where the Teredo was once abundant, it is now rare or not to be found; § but

* "Quantum nobis injicere terrorem valuit, quum primum nostros nefario ausu muros conscenderet, exilis bestiola! quanta fuit omnium, quamque universalis consternatio! quantus pavor! quem nec homo homini, qui sibi maxime alias ab invicem timent, incutere similem, nec armatissimi hostium imminentes exercitus excitare majorem quirent. In planctus et lamentationes, ut sunt commune hominum in calamitatibus refugium, effusis plurimis; in investigandis remediis, salubriore consilio, toti occupabantur alii."—*Sellius.* Also *Baster, Opusc. Subs.* ii. 67.

† Phil. Trans. abridg. viii. 379.

‡ Montagu Test. Brit. 530. This author suggests a coating of pounded flint or glass, laid on the timber with a firm cement, as probably an efficient remedy.—*Ibid.* 561. The bitter juice of the great American aloe, mixed with pitch, is said to be a preservative.—*Lin. Corresp.* i. 133.

§ Osler in Phil. Trans. an. 1826. part iii. 358.—Dr. Paris, however, on

in other parts it has still a residence, and within these few years it has materially injured or destroyed many of the piles used in the construction of the pier at Portpatrick, on the coast of Ayrshire; and the Limnoria terebrans, a crustaceous insect, co-operating with it, the result of their united efforts "can hardly fail to be the utter and speedy destruction of all the timber in the pier." And it may be remarked, that the size of the specimens received from this northern locality, gives no support to those who assert that the animal has degenerated in our seas, since they "equal, if not surpass, in magnitude the largest as yet stated to have been met with in the Indian ocean, having almost attained the length of two feet and a half," the ordinary length being about a foot.* The Teredo, which is not uncommon on the western coast of Ireland, has also begun the work of devastation in the harbour of Donaghadee, and at Youghal, in the county of Cork; and Mr. Ball states, "that about eight years ago, he saw several pieces of timber from the harbour of Dunmore, county of Waterford, that were perforated by the Teredo, which caused great destruction there at that time."† No sort of wood appears capable of resisting the fatal powers of this Mollusk. Teak, sissoo, and saul—Indian woods allied to the teak but of a harder quality—are all eaten through in a short time; British oak and cedar with still greater ease; and of course in such soft woods as alder and pine it works much more speedily and successfully, driving the bore always in the direction of the grain, whether the position of the wood be perpendicular or otherwise.‡

Ask your gardener why, in the spring especially, he with sedulous care draws layers of quicklime and ashes round his beds, or sprinkles them with lime water, and he will tell you that all this precaution is necessary to protect his early crops from the ravages of snails and slugs, than which he has no more mischievous annoyers: and for greater safety he places half decayed or greasy leaves, tiles, and other unseemly

the authority of Mr. Knowles, says it is abundant at Plymouth.—*Life of Davy*, ii. 224. And Mr. Osler's statement is contradicted by Dr. Moore.—*Charlesw. Mag. N. Hist.* ii. 206; and iii. 197.

* Thompson in Edin. New Phil. Journ. xviii. 122.—The longest which Sellius met with in Holland were thirteen inches, but trustworthy witnesses assured him they had seen specimens three feet long.—*De Tered.* 6.

† Edin. New Phil. Journ. xviii. 130.

‡ The experiments made by Mr. John Cooper, of Dover, shew "that kyanizing timber does not in any degree protect it from the worm;" nor saturating it with copperas water. The African oak resisted the attacks of it better than either fir or English oak; and teak appears to have been uninjured.—See *Athenæum*, Sept. 12th, 1840, p. 718.

things in various parts of the garden to entice them by food more savoury to their taste, or to lure them to destruction by affording deceptive places of shelter. The most destructive species in this country are the grey and black slugs and the garden snail (Helix aspersa, Fig. 1, *a*); in Provence and Languedoc, the Bulimus decollatus takes the lead;* in the wine countries, Helix pomatia and several others of the same genus destroy the vine when it puts forth its tender buds and first leaves, and hence the keepers anxiously gather and tread them under foot; "this," says Swammerdam, "I have seen transacted as a work of great consequence in France:"† and even from New South Wales we hear complaints of a small species of slug, which absolutely destroys some of the gardens.‡ The farmer finds them a still more serious pest. In wet seasons, the slug propagates with such rapidity, that a wheat crop, after a green crop of clover, tares, or beans, is very uncertain, according to Mr. Sinclair, "and may be said always to fail." You cannot look over the agricultural reports in our newspapers, without seeing frequent notices of the ravages of these apparently insignificant creatures; and the damage they annually do to corn, clover, and turnips, is really very great. Topical remedies are here of little use; the numbers of the host, and the extent of their field, their tenacity of life and mode of concealment render such means nugatory, or at least of very partial benefit, as almost every farmer will assure you.§

Had you a spark of the amiable credulousness of our forefathers; or were you one of those accommodating good-natured people who, like the brother in a tale of Mr. Crabbe's, are ever

> "ready wonders to receive,
> Prone to assent and willing to believe,"

this would be my place to speak of "things that are rather wonderful than true,"—of a cuttle "in the ocean of Gades, between Portugal and Andalusia," which, like a mighty great tree, spread abroad its arms "that in regard thereof onely, it is thought verily it never entred into the streights or narrow sea thereby of Gibraltar:" of another with a head as large as a hogshead, and with arms thirty feet long, furnished with cups like great basons, capable of holding four or five gallons apiece, and which, being over fond of salt fish, used to ven-

* Encycl. Meth. i. 326.
† Book of Nature, 49.
‡ Cunningham New S. Wales, i. 328.
§ Holdich on the Weeds of Agriculture, 75—77.

ture ashore and pilfer the sailor's stores, until he was killed in a desperate battle with dogs and men,—"in summe, he made such good shift for himselfe, that hardly and with much adoe they could kill him, albeit he received many a wound by trout-spears which they launced at him." Such tales, which assuredly disprove the vulgar notion that naturalists are mere matter-of-fact men, void of imagination, are not confined to the pages of Pliny: similar, or not more credible ones, may be found in works of comparatively modern date. The author of one of these is confident that the famous kraken of the northern seas,

> "——— on the deep
> Stretcht like a promontorie"—

was the product of no Scandinavian romance, but a veritable cuttle;* and others have described equally gigantic species, the inhabitants of the Indian ocean, which wrap their slimy arms round ships, and by their enormous weight and muscular power, drag the vessel and the miserable crew to the bottom, unless the sailors can quickly extricate themselves from the monster, by cutting off its arms with hatchets and sabres ready for the purpose.† It is curious to trace this story downwards. In the pages of Olaus Magnus, whose work was published in 1555, the tale is given in all its breadth, and with undoubting faith in its reality, and it was eagerly copied into the volumes of those naturalists who succeeded him; but before we reach the times of our immediate predecessors, it had become too gross for the age, yet unwilling to lose such an agreeable episode in their dry descriptions, they only curtailed it of its fair proportions, and fitted it to the then lesser appetite for marvels: the ship was now a little boat or canoe, navigated by the native Indians, who never sailed without an axe (for one was now sufficient) to lop off the arms of this dreaded cuttle.‡ At present we reject as apocryphal even this moderated edition: but Cuvier admits, that in tropical seas it does occasionally happen that certain cephalopods will entwine their arms round the legs of swimmers, and, by impeding their motions, bring them to a watery

* The story of the Kraken cuttlefish was invented by Olaus Magnus, Archbishop of Upsall.—See *Cuv. Hist. des Sc. Nat.* ii. p. 109. The reader will find some additional particulars to those we have adduced in my friend Dr. Hamilton's work on the "Amphibious Carnivora" (Naturalist's Library, Mammalia, viii.), p. 328—336; and the Plate 30, copied from Denys Montford, represents an Octopus in the act of dragging a ship to the bottom.

† For this, and stories equally wonderful and incredible, it is sufficient to refer to Aldrovandus, Opera, v. 7, 33, &c.

‡ Pennant Brit. Zool. iv. 116.

grave.* I believe that no unquestioned example of such an accident can be quoted to corroborate this statement, although in thus treating the subject I expose myself to the rebuke of Malte-Brun, who thinks that we over-act the part of the sceptic in disbelieving "those very circumstantial accounts, both of the ancients and the moderns."† That the cephalopods have size and strength enough for the truculent deeds ascribed to them may be admitted, but the will and the necessary agility is wanting. Mr. Pennant, in reference to the Octopus vulgaris, says, "a friend of mine, long resident among the Indian isles, and a diligent observer of nature, informed me that the natives affirm that some have been seen two fathoms broad over their centre, and each arm nine fathoms long." "The natives of the Polynesian Islands, who dive for shell-fish," I can tell you on the authority of Mr. Owen, "have a well-founded dread and abhorrence" of the Onychoteuthis; and, considering its size and formidable armature, one cannot feel surprised that their fears should have exaggerated its destructive attributes. The celebrated diver, Pescecola, whom the Emperor Frederic II. employed to descend into the Strait of Messina, saw there, with horror, enormous cuttle-fish attached to the rocks, the arms of which, being several yards long, were more than sufficient to strangle a man.‡ Mrs. Graham speaks of having seen a species, the arms of which were eighteen feet in length; and Sander-Rang met at sea with a kind of Octopus, with short arms, as big as a wine cask; hence this excellent naturalist is induced almost to believe that the stories of the kraken, and other gigantic cephalopods, are only a little exaggerated and emblazoned.§

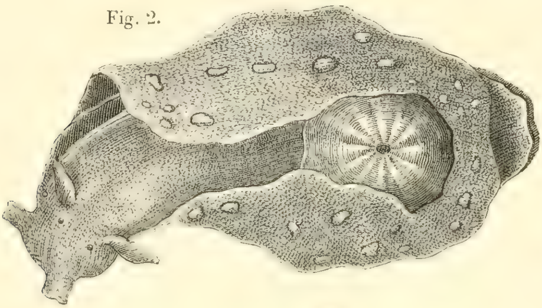
* Mem. sur les Mollusques, i. 4. Plin. Hist. Nat. ix. cap. 48.—"The cuttlefish of the Indian seas are said to be sometimes so large as to attack the pearl-divers, and strangle them in the serpent folds of their arm-like feet. We by no means think this account is devoid of truth; for even in the temperate regions of Europe, we have been frequently assured, by the Sicilian fishermen, that these animals instinctively cling to living bodies that come in their way, and that many instances have occurred, among the coral-divers, where life has been thus endangered. We have ourselves seen an undescribed species, not uncommon on the coast of Messina, whose arms were much thicker than the wrist of an ordinary man: this species is equally dreaded by the Sicilian mariners, although, on account of its delicate taste, it is sought after, and much prized, as an article of food."—Swainson in *Murray's Encyclop. of Geography*, p. 861. Lond. 1840.

† Syst. of Geography, i. 504. ‡ Ibid. i. 316.

§ Manuel, 86. Mr. Gray says that the largest cuttle which has been "zoologically described," is only twenty-seven inches in length and fourteen inches broad.—*Spic. Zool.* 3. But Owen, in *Cyclop. Anat. et Phys.* i. 529, mentions an Onychoteuthis which, from its remains preserved in the Hunterian Museum, must have measured at least six feet from the end of the tail to the end of the tentacles.

The name of the Sea-hare, or Lepus marinus, may not be unknown to you, for, having acquired some notoriety as a poison among the Romans, it is occasionally mentioned by their classical authors. The animal is a Mollusk, not very unlike a snail, and has got its Roman appellation because, says Pliny, it resembles a hare in colour; but since this is not the case, others say from some distant resemblance which a pliant fancy may find in its unformed shape to a hare in a crouching position.*

Fig. 2.



It held, or was supposed to hold, such a noxious sympathy with man, that the "onely aspect thereof" was poisonous to some; to women great with child the sight produced untimely labour, and hence it was employed to discover concealed pregnancy; the touch of it was fatal, some say, to the man who handled, others to the Mollusk, which latter doubtless would be the more probable result; while others affirmed only that the hair fell from the parts with which it came in contact; and all agreed that the odious fœtor which issued from the body occasioned sickness and overturnings of the stomach. That such a creature should afford a potent poison was a reasonable inference, and it certainly formed one ingredient of some of the poisonous draughts so much resorted to in the corrupt days of Rome. Locusta used it to destroy such as were inimical to Nero; it entered into the fatal potion which she prepared for the tyrant himself, and which he had not resolution to swallow; and Domitian was accused of having given it to his brother Titus. To search after the sea-hare was to render oneself suspected; and when Apuleius was accused of magic, because, forsooth, he had induced a rich widow to marry him, the principal proof against him was that he had hired the fishermen to procure him this fearful

* See Swainson's figure of his Aplysia sicula, in his Treat. Malacology, p. 247, fig. 45.

animal.* The operation of the poison was not immediate. "This poison," according to Pliny, "hath no set and prefinite time wherein it killeth any body;" but the victim lived as many days as the hare had lived, subsequent to its removal from the sea; and being believed besides to betray itself by the person poisoned exhaling the scent of the snail and some other peculiar symptoms, it was not often resorted to.†

What proportion of truth there is in this account, it is not easy to decide. I am not prepared to reject the whole, as some modern authors have done, who believe that the singular conformation of the Aplysia, for so the animal is now designated by naturalists, and the power it possesses of discharging at pleasure large quantities of a fluid of the richest purple colour, have given rise to the whole tale. Cuvier tells us that the species observed by him at Marseilles exhaled merely a slight acid smell, and the fishermen there knew nothing of any noxious property it had.‡ Having kept them a long time in confinement, and repeatedly handled them, I can confirm Montagu's statement, that our British species are equally harmless and inoffensive; but the question has reference not to these, but to the larger species, which inhabit the Indian ocean or the shores of southern Europe; and, to pass over the authority of Rondeletius, who, however, details a curious case, which would seem to prove that its virtue to effect abortion is far from being imaginary,§ the account which Bohadtch gives of the latter verifies to a certain extent the ancient history. He tells us, that the Lernæa|| (Fig. 2)

* "Cette ridicule accusation était basée sur ce fait, qu'on l'avait vu observer des lièvres marins, gros mollusques qui jouaient un grand rôle dans les operations magiques. Dans sa défense, Apulée répondit qu'en effet il avait observé des lièvres marins, mais seulement dans le but de satisfaire une curiosité qui n'offrait rien de condamnable."—*Cuvier Hist. des Sc. Nat.* i. 287.

† Holland's Plinie, i. 264, ii. 427. Beckman's Hist. of Inventions, i. 82. Bohadtch de Anim. Marin. 49. Cuvier Mem. ix. 2, 3. The symptoms have been enumerated in the following verses, quoted by Aldrovandus, Opera, v. 87:—

"Post bibitum hoc virus viridis stagnantia fellis
Excrementa manent, tenebroso lumina visu
Caligant, liquidæ abeunt in corpore carnes:
Nausea adest, tumet alta cutis, talique calescunt:
Subque cavis oculis, roseo fucata rubore
Apparet facies, sistensque urina moratur,
Quæ nunc purpureo, nunc sanguineo esse colore
Cernitur; et quemcunque videt contemnere piscem
Assolet aversans, ut quælibet æquoris æger."

‡ Mem. ix. 11.

§ Aldrovand. Oper. v. 86.

|| The Aplysia leporina of Delle Chiaie, Anim. s. Vert. Nap. i. p. 71.—

abounds in the bay of Naples, where the fishermen excused themselves for not bringing it to him, saying it was a filthy thing which stank abominably. When removed from the sea, and placed in a vessel, there exuded a large quantity of a limpid, somewhat mucilaginous fluid, exhaling a sweetish, sickening, peculiar smell; but besides this, and distinct from its purple secretion, the Aplysia excretes also a milky liquor, formed in an internal conglomerate gland, which seems to be analogous to the kidney of vertebrate animals. As often as he took the Aplysia from the vase of sea-water and placed it on a plate with the view of more narrowly examining its structure, the room was filled with a most fœtid nauseous odour, compelling his wife and brother to leave the room, lest sickness and vomiting should follow. He himself could scarcely endure it, and during the examination had repeatedly to go out and breathe a purer air. His hands and cheeks swelled after handling the creature for any length of time, and as often as it ejaculated its milky secretion; but he is uncertain whether the swelling of the face proceeded from the halitus merely, or from having accidentally touched it with the hand besmeared with the liquid; probably the latter was the real cause, for when he purposely applied some of it to the chin, some hairs fell from the part.* The Aplysia then appears to possess the depilatory properties ascribed to it by Pliny; but it is obvious that were it indeed poisonous, the odious smell amply secures the safety of those exposed to its action.

There are some less doubtful poisonous Mollusca. Delle Chiaie mentions it as a fact, that the fresh-water mussel and oyster become poisonous in summer, on which account their sale is prohibited during that season in all southern Europe; and we, in the north, are as effectually restrained from their use, by a popular tradition of their unwholesomeness in the

This author says of the Aplysiæ in general: "ad nauseam usque fœtidissimæ," p. 72. An Aplysia which Mr. Darwin met with at St. Jago, exudes an acid secretion which "causes a sharp, stinging sensation, similar to that produced by the Physalia, or Portuguese man-of-war."—*Voy. of the Beagle*, iii. p. 6.

* De Anim. Mar. 2, 7, 35, 50, 51.—"A sailor happened to take a Laplysia in the Mediterranean: it gave him such instantaneous and excruciating pain as to cause an inflammation, and the poor man lost his arm; and so sensible are the fishermen of the poisonous quality of the mucus which oozes from its body, that they will not on any account touch it."—*Barbut Gen. Verm.* viii. I have not traced Barbut's story to its source, but he is an author of little credit. The hurtful properties of the Aplysia have been also attributed to the Tethys. The Sea-hare of Osbeck, Voy. to China, ii. 114, is a different and harmless animal: the Scyllæa pelagica.

months that have no R in their names. * It seems certain also that oysters, in general wholesome and easy of digestion, do occasionally become noxious when in season, as was partially observed in Holland during the year 1821. † Lentilius mentions that when he was at the Hague in 1713, a certain ambassador gave a luxurious supper to some of both sexes of his own rank, and that no delicacy might be wanting oysters of a green colour were procured from England. All who eat of these were immediately seized with severe colics, and were with difficulty cured. It was afterwards ascertained, says Lentilius, that the merchant, whom he anathematizes with his whole race, had pawned upon the ambassador some common oysters, tinted with copper, for the true greens.‡ In the West Indies, some suspicion is attached to those oysters which adhere to the mangrove trees; and in China, as I am informed by my friend Dr. W. Baird, the sailors in our India merchantmen are prohibited from purchasing a large clustered kind of oyster, taken from a bed near the mouth of the river at Whampoa, and brought for sale by the natives, it having been found that they often were the cause of unpleasant symptoms. § On the shores of the West Indies, there is found a large pale Chiton, said to be poisonous; while again in the East, the fish of Mitra episcopalis enjoys, probably unjustly, the same reputation, but you must be guarded against the assertion of those who say that this Mollusk wounds them who would touch it with a kind of pointed trunk; || this can only be the proboscis, an instrument unfit for the purpose, but of extraordinary length, the animal being able, according to Mr. Stutchbury, to project it to the distance of five inches. ¶ But certainly of all Mollusca the

* "Now the fishes called oysters,
Are in their operative moistures;
For now the month hath yet an R in 't,
Astrologers do see so far in 't."

—From "Poor Robin," an almanack for 1685, quoted in *Gentlem. Mag.* v. xv. n. s. p. 607.

† Edin. Med. Surg. Journ. xviii. 320. See also Christison on Poisons, p. 469, for some additional examples. "Dr. Clarke believes that even wholesome oysters have a tendency to act deleteriously on women immediately after delivery. He asserts that he has repeatedly found them to induce apoplexy or convulsions; that the symptoms generally came on the day after the oysters were taken; and that two cases of the kind proved fatal."

‡ Ephemerid. Acad. Leopold. cent. 8, 450.

§ Osbeck mentions these oysters, "which the Chinese called Hao." "It was plainly visible," he adds, "that they came out of a clayey bottom," but he says nothing of any injurious quality they had.—*Voyage to China*, ii. 30.

|| Turt Gmel. iv. 377.

¶ Gray Spic. Zool. 4. See a figure of it in Swainson's "Malacology," p. 128, no. 13; and in Mrs. Gray's Fig. Mollusc. Anim. pl. 28, fig. 6.

Mussel (Mytilus edulis) is that which proves most frequently poisonous. I have known them to produce an itchy eruption and swelling over the whole body, attended with great anxiety and considerable fever. "On some parts of the coast of Yorkshire, where mussels are abundant, a belief is prevalent among the people that they are poisonous, and they are consequently never eaten."* Many cases are on record in which their use has proved fatal. A case, says Dr. Bateman, is mentioned by Ammans and Valentinus, in which a man died so suddenly after eating mussels, that suspicion of having administered poison fell upon his wife. Some of Captain Vancouver's men having breakfasted on roasted mussels, were soon after seized with a numbness about their faces and extremities; their whole bodies were shortly affected in the same manner, attended with sickness and giddiness, and one died. Of the mussels of Van Dieman's Land, Captain Freycinet reports that they often enclose a small crab, or little greyish pearls; such mussels ought to be avoided, since they are liable to occasion severe colics.† In the month of June, 1827, a great number of the poor in Leith were poisoned by eating these shell-fish, which they procured from the docks. "The town," says Dr. Combe, "was in a ferment, and the magistrates, with great propriety, issued a warning against the use of the mussels. Many deaths were reported, and hundreds of individuals were stated to be suffering under it. Luckily matters were not so deplorable; but we ascertained that, in addition to the man mentioned before, the companion of our patient, an elderly woman, had died. In all, about thirty cases occurred, with great uniformity of symptoms, but varying very much in severity: but none, so far as I know, have left any permanent bad effects."‡ To what cause these deleterious effects are to be ascribed is uncertain; for mussels, you are aware, may commonly be eaten with impunity. The common people attribute all the symptoms to the person having unwarily swallowed the beard or byssus of the fish, but there is no doubt that the opinion is erroneous. Some of the learned ascribe them to the presence of parasitical worms, to the spawn of star-fish, or to microscopical medusæ; others, to the mussel having fed on some poisonous articles, more particularly on the ores of copper; others believe the mussels to be in a diseased condition, or in a state of putrefaction; and others refer all to the peculiar

* Bateman on Cut. Diseases, 89.

† Voy. aux Terres Aust. 43.

‡ Edin. Med. Surg. Journ. xxix. 88. See also the Med. Quart. Review, iii. 179; and Christison on Poisons, 462—8.

idiosyncrasies of the sufferers. In many cases this latter explanation will suffice, but sometimes, as in the Leith cases, it is obviously insufficient. Drs. Combe and Christison have reviewed with candour the other supposed causes, and finding reason to refuse assent to any which has been alleged, they agree that the effects seem to be best explained by attributing them to a peculiar poison generated in the fish under unknown circumstances, although the latter eminent physician and chemist admits that in the deleterious mussels he could not detect any principle which did not equally exist in the wholesome ones. It is quite certain that putridity can have no existence as a cause, for the fish are eaten fresh or alive ; and the most delicate chemical tests give no indications of the presence of copper, which, moreover, produces symptoms of a different character. Delle Chiaie has demonstrated that in many instances the poison is generated with those changes in the system that result from the pregnancy of the Mollusks. The Arca noæ, Murex brandaris, and M. trunculus, are great favourites of the Neapolitans, who eat them with perfect safety in all seasons except in summer or the beginning of autumn, when they are dangerous. This author has recorded two examples of their fatal effects at this season ; and another of a party of twelve persons who were poisoned with the Arca noæ, although the only one of the party who died was the wife of the host. On dissection, he found that all these Mollusca, at this season of fecundity, were greatly altered, more especially the gland that secretes the purple fluid; and the ovaries, the branchiæ, and indeed the whole body were filled with a clammy liquid.* I am inclined to believe, with Dr. Thomas,† that in other cases the poisonous principle proceeds from some particular food which, not fatal to the Mollusks, yet generates a diseased condition of the body deadly to other creatures. The Leith mussels were living in a dock, where we may presume they were nurtured and fattened amid putrescent matters; and Dr. Coldstream, than whom no one is better qualified to decide the point, gave it as his opinion that the liver was larger, darker, and more brittle than in the wholesome fish, and satisfied Dr. Christison that there was a difference of the kind. The oysters by which, not long ago, some people were poisoned at Havre, were procured from an artificial bed, which had been established near the exit of the drain of a public necessary : and Dr. Chisholm mentions a fact which bears on the question, and seems to prove that copper communicates some perni-

* Anim. s. Vert. Nap. ii.

† Pract. of Physic, 679.

cious quality to the oyster, probably by acting as the cause of some disease. The fact was communicated to Dr. Chisholm, "at St. Croix, by the late Mr. William Newton, of that island. Some time after the Santa Monica, British frigate, was cast away on the coast of the island of St. John, one of the Virgin Islands, oysters grew on her bottom, which was coppered. Many people ate of these oysters, and although the consequence was in no instance fatal, it was such as was dangerous and unpleasant in a very great degree, producing cholera and excruciating tormina."* Further observations and experiments are, however, necessary to elucidate this interesting question. Lamouroux states that mussels never become poisonous unless they are exposed alternately to the air and the sea in their place of attachment, and unless the sea flows in gently over them without any surf; but on this statement it may be remarked that mussels are almost always found in such localities, where they certainly thrive best.

* Edin. Med. Surg. Journ. iv. 400.

LETTER III.

THE MOLLUSCA CONSIDERED AS EDIBLE ANIMALS.

You may often have heard it observed that living beings form an uninterrupted chain,—

——"lessening down
From Infinite Perfection to the brink
Of dreary nothing,"—

from which no link can be removed without disordering the uniformity of the whole. The comparison, in whichever way applied, is not altogether correct; for there are yet at least many evident breaks to the continuity of animals, many incompleted or absent circles in the scheme of their quinary involutions, whether we look to their external appearance or internal organization. If the simile is intended merely as an illustration of their dependence upon one another for the supply of some necessary want, it is still liable to exception, for there can be no doubt that many species of the Mollusca in particular, which have lived under the present state of things, have been lost and exterminated, while others their contemporaries survive to play their part among living entities. You must therefore receive with many limitations the language of some writers, who love to declaim upon the possible effects of the annihilation of even the most insignificant species. It might involve, they say, the destruction of some other immediately dependent on it for its wants; the extermination of this again would be but the precursor of another's death; another still would succeed, and ruin would spread around, until man himself fell in its embrace. Impressed with this view, which is a very popular one, a poet and naturalist has said,—

"Each shell, each crawling insect holds a rank
Important in the plan of Him, who fram'd
This scale of beings; holds a rank, which lost
Would break the chain, and leave behind a gap
Which Nature's self would rue."*

* Stillingfleet's Select Works, ii. i. 46. See Cuvier's remarks on this subject in his Hist. des Sc. Nat. iii. p. 54, &c.; and Miller's Old Red Sandstone, p. 66.

It is by thus associating it with religious sentiment—with the presumed immutability and perfection of the present system—that currency has been given to the opinion: but truly the existence of animals and of man is held on no such slight and uncertain tenure, and it has been proved that the extinction of many species has been attended with no ruinous result.* That animals are nevertheless more or less dependent on one another is evident: one species may disappear, and its loss be unfelt; but were the process of extinction to proceed from species to races and families, the resources of some of the remainder must fail, and it is improbable that their constitutions would be pliable enough to accommodate itself without injury to subsistence of a new character. It is in fact the dependency which animals have upon each other for a supply of necessary food, that mainly concatenates the whole.† On contemplating this part of creation, we behold a scene of havoc and devastation perpetually and everywhere going on, so that "there is not," as Smellie has remarked, "perhaps a single species (or family) of animated beings, whose existence depends not, more or less, upon the death and destruction of others." That this order of things, however cruel it may appear to us, is subservient to the good of the whole, cannot admit of any doubt; and it is my purpose, in the present letter, to convince you by some detail of facts, that molluscous animals in this relation play a not unimportant part. But, as it would be tedious to enumerate all or the greater portion of the animals to which they furnish nutriment, we shall confine ourselves to those which possess some peculiar interest, or which minister directly to the luxuries or necessities of man.

To commence with quadrupeds and mammals. It is nothing surprising that the different species of walrus and narwhales, inhabitants of ocean, should feed partly or principally on cuttles and shell-fish; nor that the whale should obtain a large proportion of the nutriment for its huge growth from the myriads of little pteropod Mollusca, which crowd the Arctic seas;‡ but perhaps you would not expect to find among molluscous feeders animals which are strictly terrestrial. Yet the ouran-outang and the preacher-monkey, it is said, often descend to the sea to devour what shell-fish they may find strewed upon the shores. The former, according to Carreri Gemelli, feed in particular on a large species of

* Lyell's Geology, ii. 128.

† Mr. C. Darwin has some interesting remarks bearing on this question in the Voy. of the Adventure and Beagle, 304-5.

‡ Ent. Mag. iii. 433.

oyster, and fearful of inserting their paws between the open valves, lest the oyster should close and crush them, they first place a tolerably large stone within the shell, and then drag out their victim with safety.* The latter are no less ingenious. Dampier saw several of them take up oysters from the beach, lay them on a stone, and beat them with another till they demolished the shells. Wafer observed the monkeys in the island of Gorgonia to proceed in a similar manner; † and those of the Cape of Good Hope, if we are to credit La Loubere, perpetually amuse themselves by transporting shells from the shore to the tops of the mountains, ‡ with the intention undoubtedly of devouring them at leisure. Even the fox, when pressed by hunger, will deign to eat mussels and other bivalves; and the racoon, whose fur is esteemed by hatters next in value to that of the beaver, when near the shore lives much on them, more particularly on oysters. We are told that it will watch the opening of the shells, dexterously put in its paw, and tear out the contents; but when it is added that the oyster, by a sudden closure of its shell, occasionally catches the thief and detains him until he is drowned by the return of the tide, the story assumes a very apocryphal character. § The American musk-rat, and an animal allied to it in New South Wales, feed on the large mussels so abundant in the rivers and lagoons of those countries; the animals dive for the shells and drag them to the land, where they break them and devour the inmates at leisure. || Our own brown rat, having settled in many islets at a great distance from the large islands of the outer Hebrides, finds means of existence there in the shell-fish and crustacea of the shore; ¶ and according to Mr. Jesse, the same rat,

* "To this instance of instinct, however," says Mr. Swainson, "we must withhold our belief: it is not only too rational, but there is nothing yet known, to make us believe that this quadruped feeds, in a state of nature, upon animal food."—On the Hab. and Inst. of Anim. in *Lard. Cyclop.* p. 21.

† Bingley's Animal Biography.

‡ Buffon Nat. Hist. Eng. Trans. i. 221.

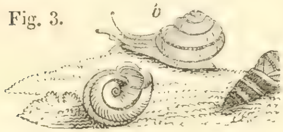
§ "'The Inverness Courier' states that immense mussels, some of which are almost as large as a man's shoe, are found at Ardinisgain, on Loch Carron. A few days since, one of these mussels was left uncovered by a spring ebb tide, and was induced by the rays of the sun to open itself. While thus open, it was observed by a prowling fox, which thrust its tongue into the shell in the hope of securing the fish; but the mussel instantly closed on the tongue of the fox, which was retained a prisoner until drowned by the rising tide."—*Berwick Advertiser*, Jan. 15, 1848. We hope that the fact is not as false as the grammar.

|| Cunningham's N. S. Wales, i. 311.

¶ Edin. Journ. Nat. & Geogr. Sc. ii. 163.

satiated it may be with the common fare, will sometimes select the common brown snail (Helix aspersa) as a pleasant entremet.* In some parts of England it is a prevalent and probably a correct opinion, that the shelled snails contribute much to the fattening of their sheep. On the hill above Whitsand Bay, in Cornwall, and in the south of Devonshire, the Bulimus acutus (Fig. 3, *a*), and the Helix virgata (*b*), which are found there in vast profusion, are considered to have this good effect; and it is indeed impossible that the sheep can browse on the short grass of the places just mentioned, without devouring a prodigious quantity of them, especially in the night, or after rain, when the Bulimi and Helices ascend the stunted blades. "The sweetest mutton," says Borlase, "is reckoned to be that of the smallest sheep, which usually feed on the commons where the sands are scarce covered with the green sod, and the grass exceedingly short; such are the towens or sand hillocks in Piran Sand, Gwythien, Philac, and Senan-green near the Land's End, and elsewhere in like situations. From these sands come forth snails of the turbinated kind, but of different species, and all sizes, from the adult to the smallest just from the egg; these spread themselves over the plains early in the morning, and whilst they are in quest of their own food among the dews, yield a most fattening nourishment to the sheep."†

Fig. 3.



Among birds the Mollusca have many enemies. Several of the duck and gull tribes, as you might anticipate, derive at

* Gleanings, second series, 316.—"A tradesman of Plymouth, having lately placed some oysters in a cupboard, was surprised at finding, in the morning, a mouse caught by the tail, by the sudden collapsing of the shell. About forty years since at Ashburton, at the house of Mrs. Allridge, known by the name of the New Inn, a dish of Wembury oysters was laid in a cellar. A large oyster soon expanded its shell, and at the instant two mice pounced upon the 'living luxury,' and were at once crushed between the valves. The oyster, with the two mice dangling from its shell, was for a long time exhibited as a curiosity. Carew, in his 'History of Cornwall,' tells of an oyster that closed on *three* mice.—*Bell's Weekly Messenger* for Jan. 7, 1821. An apposite instance is also epigrammatically recorded in the "Greek Anthology":—

"Omnia contrectans, lychnos quoque rodere suetus,
Mus, labiis concham forte patere videt.
Sed cupido falsam morsu vix attigit escam
Cum patulam clausit subdola Concha domum.
Mus stupet, et vitam nec opino carcere perdens,
Muscipula gemuit se periisse nova."

† Hist. of Cornwall, 286.

least a portion of their subsistence from them.* The pied oyster-catcher receives its name from the circumstance of feeding on oysters and limpets (Patella vulgata), and its bill is so well adapted to the purpose of forcing asunder the valves of the one, and of raising the other from the rock, that "the Author of Nature," as Derham says, "seems to have framed it purely for that use." Several kinds of crows likewise prey upon shell-fish, especially upon the fresh-water mussels, and the manner in which they force the stronghold of their victims is very remarkable. A friend of Dr. Darwin's saw above a hundred crows, on the northern coast of Ireland, at once, preying upon mussels. Each crow took a mussel up in the air twenty or forty yards high, and let it fall on the stones, and thus broke the shell. Many authorities might be adduced in corroboration of this statement.† In Southern Africa so many of the Testacea are consumed by these and other birds, as to have given rise to an opinion that the marine shells found buried in the distant plains, or in the sides of the mountains, have been carried there by their agency, and not, as is generally supposed, by eruptions of the sea. Mr. Barrow, who is of this opinion, tells us, in confirmation of it, that "there is scarcely a sheltered cavern in the sides of the mountains that arise immediately from the sea, where living shell-fish may not be found any day of the year. Crows even, and vultures, as well as aquatic birds, detach the shell-fish from the rocks, and mount with them into the air: shells thus carried are said to be frequently found on the very summit even of the Table Mountain. In one cavern at the point of Mussel Bay," he adds, "I disturbed some thousands of birds, and found as many thousands of living shell-fish scattered on the surface of a heap of shells, that for aught I know, would have filled as many thousand waggons."‡ The story, therefore, of the ancient philosopher whose bald pate one of these unlucky birds mistook for a stone, and dropped a shell upon it, killing at once the sage and cracking the oyster, is not so tramontane as to stumble all belief!

Land shells furnish a few birds with part of their sustenance, and the principal of these are two well-known songsters, the blackbird and the thrush. They,

—— "whose notes
Nice finger'd Art must emulate in vain,"

* "The abundance of shell-fish in Conception entices a great many birds within the bay."—*Beechy's Voyage*, i. 31.

† Blackwall's Research. in Zoology, 154-5.

‡ Travels in Southern Africa, i. 8.—On the summit of the chain of mountains which border the Icy Sea, "to the east of Simovic Retchinoie, is an

depend in great measure, when winter has destroyed their summer food, on the more common species of Helices, especially on H. nemoralis. These they carry in their bills to a convenient station and break very dexterously by reiterated strokes against some stone; and it is not uncommon to find a great quantity of fragments of shells together, as if brought to one particular stone for this very purpose. It appears that the thrush also feeds her callow young with Helices. The bearded titmouse feeds on Succinea amphibia and other small terrestrial Mollusca (Pupæ), but, unlike the thrush, it swallows the shells entire, which are broken down by the action of the stomach, the trituration being completed by attrition against numerous sharp angular fragments of quartz instinctively swallowed at the same time.*

Fishes are stupid animals, and incapable, apparently, of planning any stratagem by which they might surprise the unheeding conch. You might imagine, therefore, that our favourites, "in their grotto works enclosed," were sufficiently secure from their hostile attempts. It is not so. They are the frequent victims, not indeed of the cunning, but of the indiscriminating and almost insatiable appetite, of fishes; and from the stomach of a cod or flounder you may procure many a shell, not otherwise so easily attainable. When indeed we call to recollection the vast and incalculable number of molluscous animals which crawl on the bottom, or swim in the bosom of the ocean, and the voracious habits of the swarms of fish which everywhere traverse it, we may reasonably conclude that their utility in this respect in the economy of nature is very great, and beyond human ken. And not only do the shell-fish nourish, but it has been presumed, or perhaps proved, that they impart a peculiar flavour to at least some of their devourers, which greatly enhanced their value in the esteem of Roman epicures. Thus Martial sings,—

"No praise, no price a gilthead e'er will take,
Unfed with oysters of the Lucrine lake:" †

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amazing bed of small mussels, of a species not observed in the subjacent sea. I think them brought there by sea-fowl, to eat at leisure."—*Pennant, Arctic Zool. Introd. C.*

* Mag. Nat. Hist. iii. 238, 9.—In the Hebrides the Thrush feeds on the Turbo littoreus and Trochus conuloides, much thicker and stronger shells than the Helix, but which it breaks in the same manner.—*Edin. Journ. of Nat. & Geogr. Sc.* i. 66. The Rock Pigeon of these islands feeds chiefly on Helix ericetorum and Bulimus acutus.—*Lib. cit.* ii. 325.

† "Non omnis laudem pretiumque aurata meretur,
Sed cui solus erit concha Lucrina cibus."

Hence Pope in his "Satires:"

"Let me extol a cat on oysters fed;
I'll have a party at the Bedford-head."

and, according to Pliny, the mullets which savoured of their food were the most prized—"laudatissimi conchylium sapiunt;" and these, as saith honest Izaak Walton, "they would purchase at rates, rather to be wondered at than believed."

I must here digress a little, to advert to the more direct utility of the Mollusca in furnishing to the fisherman the means of enticing to his snare the hapless victims of his art. On every coast the shell-fish peculiar to it are extensively employed for this purpose, but we may confine ourselves to those used by our own fishermen. At Salcomb, on the coast of South Devon, the Pholas dactylus is found in great abundance, and is used with success. Many boat-loads of a river mussel (Unio margaritiferus) are taken from the mouth of the Ythen, a river not far from Aberdeen, and employed in the fisheries of cod and ling established near Peterhead. The clam (Pecten opercularis), and the great mussel (Modiola vulgaris), are resorted to in other parts of the kingdom, and are eagerly sought after as a bait for cod; and you are aware that many thousands of limpets (Patella vulgata) and of the common mussel (Mytilus edulis), are daily torn from the rocks, to ensnare the common fishes of our coasts, and thus contribute materially to add one more luxury to the tables of the rich, and to give to the poor a cheap and wholesome diet. The large whelk (Buccinum undatum), and a species of rock-shell (Fusus antiquus), may likewise be enumerated among our ordinary baits. At Portpatrick, where the former is called the Hen Buckie, it is caught for this purpose in baskets, "containing pieces of fish, which are let down in about ten fathoms water, about a quarter of a mile off the harbour or the old castle, and are drawn up daily to be emptied of the shell-fish which have crept into them to feed on the dead fish. Each shell serves to bait two hooks; so that, reckoning the number of hooks used by all the boats at 4,500, about 2,250 of these large shell-fish must be destroyed every time the lines are shot, and probably not fewer than 70,000 every year. Yet the supply chiefly obtained from a space of no great extent, seems to be even more abundant than ever."*

The Americans, in their fisheries on the banks of Newfoundland, previously to the arrival of the Capelan, bait their lines with the animal of a species of Mya, which abounds on several parts of the American coast, and which is peculiarly acceptable to the cod, so that they prove much more successful than the French who do not use it, but who, towards the

* Wilson's Voyage, i. 53.

conclusion of the season, purchase from the Americans the remaining portions of their bait, in order that they may the more speedily complete their cargo. Bellanger, who ascertained this fact, and who is well versed in Conchology, examined this Mya carefully, and found that it was a species

Fig 4.

(M. arenaria) met with abundantly on the coasts of the French channel.* But the most valuable of the Mollusca in their present view is certainly the Loligo piscatorum (Fig. 4), a species of Calamary, or as it is called by our fishermen, a

* Edin. New Phil. Journ. viii. 204. Audouin et M. Edwards' Hist. Nat. du Lit. de la France, i. 296. Dr. Gould says: "The clam (Mya arenaria) is still more important, in an economical point of view, than the oyster. It is extremely prolific; and its exhaustless banks are every day accessible during twelve of the twenty-four hours." It is used for food as well as for bait. About five thousand bushels of clams are annually brought to Boston market. Immense numbers are salted for the bank fisheries—not less than five thousand barrels every year. "Seven bushels of clams make about one barrel of bait; so that thirty or forty thousand bushels are used in this prepared state, and perhaps as many more are used from the shell. The value of the clam-bait is six or seven dollars per barrel."—*Invert. Massachus.* p. 359.

sleeve or hose-fish. With this cuttle, one half of all the cod taken at Newfoundland is caught. "It occurs in vast abundance, but at different times, on different coasts; for example, at St. Pierre in July, on the southern coasts of Newfoundland only in August, and in Bonna Bay first in September. Its vast shoals present a curious appearance, by their strongly twisted compact form. When they approach, hundreds of vessels are ready for their capture." "At this season of the year, the sea on the coast of St. Pierre is covered with from 400 to 500 sail of English and French ships, engaged in the cuttle-fish fishery."* It begins to retire from the coast in September. "During violent gales of wind," says Mr. Cormack, "hundreds of tons of them are often thrown up together in beds on the flat beaches, the decay of which spreads an intolerable effluvium around. It is made no use of except for bait; and as it maintains itself in deeper water than the capelan, instead of nets being used to take it, it is jigged,—a jigger being a number of hooks radiating from a fixed centre, made for the purpose. The cod is in best condition after having fed on it."† Another method of taking them is sometimes resorted to. Fires are made all along the shore during the night, when the Loligo, attracted by the light, approaches too near for his safety, and is left on the strand by the recess of the tide, when the fishermen go to gather them."‡

Crowds of the inferior animals certainly feed on the Mollusca; but as there is little interest in the detail, a very few examples will here suffice. There is a singular coleopterous insect, the Drilus flavescens, which is known to devour voraciously the Helix nemoralis, in the shell of which it dwells and undergoes its metamorphosis. It has been ascertained also that slugs and snails are the appropriate food of the glow-worm, nor does the shell of the snail suffice to protect it from the assault of the insect, although the combat may

* Edin. New Phil. Journ. viii. 395.

† Edin. New Phil. Journ. i. 37. The editor remarks: "The cuttlefish occurs in abundance in many of our estuaries and coasts, but has hitherto been considered as of no value. Now that it is known to form an excellent bait for cod, and even for other fishing, it is not to be doubted that it will in future, in this country, be used with equal advantage and profit as a bait for the capture of our cod, ling, &c."—The species which occurs most abundantly on the British coast is Lol. vulgaris, which would doubtless prove as attractive as the Lol. piscatorum. Mr. Couch, in his "Cornish Fauna," p. 81, says it "is a favourite bait among fishermen, few fish being able to resist it." Cuttlefish in general are extensively used for bait on the French coast.

‡ Aud. and M. Edwards lib. cit. i. 300.

last several hours."* Two small leeches (Hirudo bioculata and complanata) often wage successful war against the fresh-water snails so abundant in our ditches; and another species (H. hyalina), not so cruel in disposition, draws its nourishment from the sanies which flows from the Planorbis carinatus. Its calcareous envelop is no protection to the mussel against the wiles of the Nymphon grossipes; thousands of littoral shells are devoured by the sea anemones (Actiniæ); and the common star-fish knows so well how "to force the oyster from his close retreat," and destroys such numbers of them, that, at one period, every dredger who observed one of their enemies, and did not tread on and kill it, or throw it upon the shore, was made liable to some penalty.

Having thus taken a general survey of the predatory relation in which other animals stand with the Mollusca, let me now shew you the extent of their use in this view to man, for availing himself very liberally of the licence, "every moving thing that liveth shall be meat for you," he has added very many of them to his long dietetical list. Of these the principal, as you will at once guess, is the oyster, "the food that feeds, the living luxury," as it is described by a late poet of celebrity, though there are some who, like the great Mr. Boyle, abhor the eating of them raw, and, with another poet, are ready to exclaim,

> "That man had sure a palate cover'd o'er
> With brass or steel, that, on the rocky shore,
> First broke the oozy oyster's pearly coat,
> And risk'd the living morsel down his throat!" †

But, be that as it may, oysters are in general much esteemed, and have, for many centuries, held an eminent place amongst the delicacies of the table. The Romans, when luxury had ousted the temperance of their earlier days, preferred them to all others; and ultimately proceeded to such gross extravagance in their use, that the interference of the magistrate was called forth, and penalties inflicted on such as were convicted of importing them from a distance. "Nec potest videri satis dictum esse de his, cum palma mensarum divitum attribuatur illis," are the words of Pliny.‡ They sometimes

* Entom. Edin. 205. Mag. Nat. Hist. viii. 623.

† The language of Lentilius is similar: "Animal est aspectu et horridum et nauseosum, sive id spectes in sua concha clausum, sive apertum, ut audax fuisse credi queat, qui primum ea labris admovit."—*Ephemerid. Acad. Leopold.* cent. 8, 454. See also Seneca Epist. 95 and 108.

‡ "I had hoped," said Glaucus, in a melancholy tone, "to have procured you some oysters from Britain; but the winds that were so cruel to Cæsar have forbid us the oysters."

brought them from Britain: but those most celebrated for their sweetness and tenderness were from Cyzicus, a town of Mysia, situate in a cognominal island of the Propontis. You will also remember that those which came from the Lucrine Lake and from Brundusium had no vulgar fame, being occasionally adverted to by their poets and satirists. It was even a grave matter of dispute to which of these the preference was due; and to settle the point, or with a view, perhaps, of combining the good qualities of both, oysters were wont to be carried from Brundusium, and fed for a time in the Lucrine Lake.* Dr. Baster would persuade us that the Roman predilection for oysters was a very sanitary one:—"Living oysters," he says, "are endowed with the proper medicinal virtues; they nourish wonderfully, and solicit rest, for he who sups on oysters is wont on that night to sleep placidly; and to the valetudinary afflicted with a weak stomach, oppressed with phlegm or bile, eight, ten, or twelve raw oysters in the morning, or one hour before dinner, is more healing than any drug or mixture that apothecary can compound!"

Oysters abound on various parts of the British coast, and have become a valuable article of commerce. The south-eastern and southern shores afford the principal supply, and probably the fisheries of Essex are the most important.† The principal station of the dredging-boats is at Mersea in Blackwater, which, with the Crouch and the Coln, are the most extensive breeding-rivers in the county. "The oysters are brought from the coasts of Hampshire, Dorset, and other

"Are they in truth so delicious?" asked Lepidus, loosening to a yet more luxurious ease his ungirdled tunic.

"Why, in truth, I suspect it is the distance that gives the flavour; they want the richness of the Brundusium oyster. But at Rome no supper is complete without them."

"The poor Britons! There is some good in them after all," said Sallust; "they produce an oyster!"—*Last Days of Pompeii*, i. 47.

* "In the new moon all shell-fish fill with juice,
But not all seas the richer sort produce;
The largest in the Lucrine Lake we find,
But the Circæan are of sweeter kind."—*Francis's Horace.*

† "The best in England—fat, salt, green-finned—are bred near Colchester, where they have an excellent art to feed them in pits made for the purpose. King James was wont to say, 'he was a very valiant man who first adventured on eating of oysters.' Most probably mere hunger put men first on that trial. Thus necessity hath often been the purveyor to provide diet for delicacy itself; famine making men to find out those things which afterwards proved not only wholesome, but delicious. Oysters are the only meat which men eat alive, and yet account it no cruelty."—*Fuller's Worth. Eng.* i. 493.

maritime counties, even as far as Scotland, and laid in the beds or layings in the creeks adjoining those rivers. The number of vessels immediately employed in the dredging for oysters are about 200, from twelve to forty or fifty tons burden each, employing from 400 to 500 men and boys. The quantity of oysters bred and taken and consumed annually, mostly in London, is supposed to amount to 14,000 or 15,000 bushels. All the other fisheries connected with this part of the coast are stated to employ a capital supposed to amount from 60,000*l.* to 80,000*l.*" In various parts of Milford Haven there are likewise inexhaustible beds of oysters, of superior excellence.* But so important are the oyster-fisheries of Britain, that they have long been an object of attention to the Legislature; and they are regulated by a Court of Admiralty. In 1375 (Edward III.) it was illegal to dredge for oysters or mussels between May and Holyrood day, the 14th of September; or to keep the fry of those fish in any season.† In the month of May, the fishermen are allowed to take the oysters, in order to separate the spawn from the *cultch*,‡ the latter of which is thrown back, to preserve the bed for the future. After this month it is felony to carry away the cultch, and punishable to take any oyster, unless, when closed, a shilling will rattle between its valves. The spawn is then deposited in beds or layers formed for the purpose, and furnished with sluices, through which, at the springtides, the water is suffered to flow. This water, being stagnant, soon becomes green in warm weather; and, in a short time, the oysters acquire the same tinge, which renders them of greater value in the market. Three years, at least, are required to bring them to a marketable state; and the longer they remain, the more fat and delicate they become.§ These artificial beds, as Pliny informs us, were invented by one Sergius Arata, and first established on the Lucrine Lake, A. U. 660; and, from some circumstances mentioned by the naturalist, we may infer that the said Sergius was no loser by the

* Encyclop. Brit. Supp. iv. 269, 270.

† Nicolas's Hist. Roy. Navy, ii. 205.

‡ By this term are meant the stones, gravel, old shells, &c., to which the spawn adheres; and the reason for punishing its destruction is, that, when taken away, the ooze increases, and mussels and cockles breed on the bed, and destroy the oysters, gradually occupying all the places on which the spawn should be cast.

§ See Sprat's Hist. Roy. Soc. 308; Pennant's Brit. Zoology, iv. 227, &c.; Bingley's Animal Biography, art. Oyster; Thomson's Annals of Philosophy for January, 1818, 70; and the Brit. Cyclop. Nat. Hist. iii. 381.—M. Carbonnel received a patent for a new and simple method of establishing oyster-banks on the coasts of France, of which there is a short account in Chenu's Traité de Conchyliologie, p. 111.

speculation. In Scotland we have none of them, but eat our oysters just as they are brought from their native rocks; and though certainly inferior to the genuine "Pyefleet" or "Walfleet," yet they are no despicable dainty. The principal Scottish fishery is that at Prestonpans, in East Lothian. From this place have been sent to fatten, in bays near the mouths of the Thames and Medway, thirty cargoes in one season, each cargo consisting of 320 barrels, and each barrel containing 1,200 saleable oysters, which brought in about 2,500*l.*; the quantity consumed near the spot, and in Edinburgh, brings somewhat more; and this branch of trade gives occasional employment to about forty boats.* In Ireland, "the entrance to the Bay of Belfast, and the loughs of Strangford and Carlingford, furnish a valuable supply of oysters, which are conveyed for sale to considerable distances. The Carrickfergus oysters are large in size, and so much in demand, that their price in the Belfast market is generally from twelve to fifteen shillings per hundred of 120 oysters. It is occasionally twenty shillings; and we have known one instance in which as much as thirty shillings was paid."†

In France, British oysters, which are reckoned the best in the world, obtain a preference over their own, which nevertheless are the source of a very lucrative trade. The most esteemed are found on the coasts of Brittany,‡ and the largest on those of Normandy, whence they are transported, at a great expense, to Paris during the autumn and winter. The value of the trade may be estimated to some degree from the following details:—At Granville, a small town on the coast of Normandy, there were, in 1817, seventy-two boats employed in this fishery, which commences in the beginning of October, and ends about the middle of April; and during all that time gives work not only to the fishermen, but to many women and children, who carry the oysters to the "parks," in which they are preserved until their sale is effected. This trade yearly produces from 200,000 to 300,000 francs; and, so long as it continues, the harbour of Granville presents a very animated scene. It has employed, between the years 1816 and 1828, from 70 to 119 boats annually, averaging upwards of 400 tons in all, and manned on an average with 500 men. At Cancale, another town on the same coast, there are commonly seventy boats employed in the same way, averaging in all about 700 tons, and manned with nearly 570 men. In the year 1828, the number of oysters

* Encyclop. Brit. Supp. iv. 268.
† Patterson's Zoology for Schools, 172.
‡ Rondel. Hist. des Poiss. ii. 27.

dredged here amounted to 52,000,000, for which the return in money was 170,000 francs.* To communicate to the oysters a green colour, which, as with us, enhances their value in the market and in the estimation of the epicure, they are placed for a time in tanks, or "parks," formed in particular places near highwater mark, and into which the sea can be admitted at pleasure by means of sluices: the water being kept shallow and left at rest, is favourable to the growth of green confervæ and ulvæ; and with these there are generated at the same time innumerable minute crustaceous animalcules, which serve the oysters for food, and tincture their flesh with the desirable hue.

Almost every country can boast of its oyster; and although the species is not always the same, "yet is their meate and substance right pleasaunt in the eating." On many parts of the coast of India they occur in profusion; and at the mouths of several rivers oyster-beds have been made by the natives. The oysters of the Coromandel Coast, though by no means large, are inferior to none in any part of the world, and are best in the months of May, June, July, and August—a curious fact, for in Europe these are the very months in which they are avoided. Those brought to the Calcutta market are mostly all from Chittagong: they are very large, so much so that they require being divided before they are eaten.† The shores of China, Japan, and the numerous large islands of the Indian Ocean, are equally productive; and all voyagers agree that the large sort, which is indigenous to many parts of the coast of New Holland, is remarkable for the delicacy of its flavour. In Africa and the West, the tree-oyster (Ostrea arborea), clinging in clusters to the exposed roots of the mangrove tree, which fringes the margin of all great rivers in tropical climates within the influence of the tide, is, according to Adanson, as delicate and well tasted as our own, so that even connoisseurs have been unable to detect any difference. The negroes lop off a branch loaded with the shells, obtaining by one stroke of the axe a large supply; for if the

* Aud. and Edwards Hist. Lit. de la France, i. 41, 42, 171, 173, 179. The Cancale or Saint-Malo fishery produced in

1825	....	67,236,000 oysters	....	value	188,884 francs.
1826	....	78,480,000 „	....	„	192,000 „
1827	....	56,550,000 „	....	„	166,650 „
1828	....	52,000,000 „	....	„	170,000 „

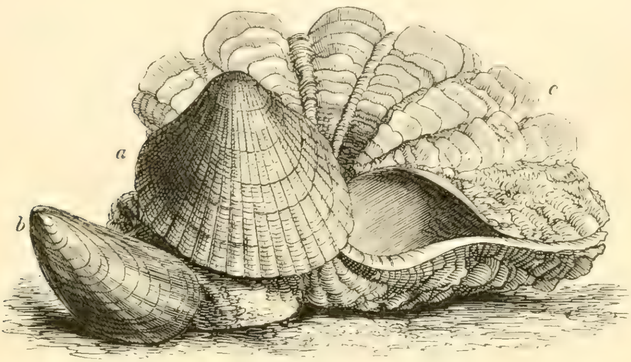
On the American oyster fisheries I refer to Dr. Gould's Report on the Invertebrata of Massachusetts, 356—9. "The whole amount of oysters used annually in Massachusetts cannot fall short of 100,000 bushels."

† Ainslie's Mat. Indica, i. 287.

branch has many offsets, the load will be enough for any one man to carry.*

The oyster is a bivalve shell, and there are many others of this class which are edible; indeed I know of none, with the few occasional exceptions formerly mentioned, which are positively hurtful. The most valuable European species are the mussel (Fig. 5, *b*) and the cockle. Large quantities of the

Fig. 5.



former are yearly taken from the shores to be used principally for bait; but they are also often eaten, roasted or pickled, or made to enter into the composition of sauces. Their fishery occupies a considerable number of persons, especially where the mussels have obtained a reputation for superior excellence. This is the case with the mussels of Buddle Bay, on the coast of Northumberland; and those of Isigny, near Bayeux, and of other places on the western coast of France, are held in high estimation. Mussels, of however inferior delicacy, are found in very great abundance on the rocks which border the coast between Saint Malo and Cancale, in the department de la Manche, where they are torn from their attachments by means of an iron hook at low water; and the annual profit of this fishery is estimated at from 2,000 to 2,500 francs.†—The cockle (Cardium edule, Fig. 5, *a*) is in season from autumn to spring, and great numbers are consumed in all our coastward towns and villages.‡ In Torbay,

* Voy. au Sénégal, 87. See more on edible mollusca in vol. i. of "The Voyage of the Adventure and Beagle."

† Lit. de la France, i. 173. For an account of the curious manner in which mussels are propagated near Rochelle, and the importance attached to the fishery there, see the Journ. de Physique, xciii. 196, &c.

‡ "The cockle-beds at the mouth of the Tees have long afforded employ-

they use the large Cardium aculeatum and C. rusticum, which abound on the Paignton sands, where, at low spring-tides, they may be observed with the fringed tubes appearing just above the surface. The neighbouring cottagers, who call them *red noses*, gather them in baskets and panniers, and after cleansing them a few hours in cold spring water, fry the fish in a batter made of crumbs of bread, producing a wholesome and savoury dish.* The Clams (Pecten) are also a much esteemed genus; the P. maximus in the south is often pickled and barrelled for sale; and the P. opercularis is commonly eaten in Scotland. The Razor-fish (Solen siliqua), common on our sandy shores, is an article of food in many places; and when they go to its capture, the Irish are said to have a song appropriate to the occasion, whence we may infer that it is a favourite with them. Whether an eastern origin for the Irish people can be with equal safety inferred from the fact, I leave others to determine; but the Japanese have the same fondness for the razor-fish, a species of which, according to Kæmpfer, "found only upon the coasts of Tsikimgo," is so highly prized, that "by express order of the prince of that country it is forbid to fish them till a sufficient quantity hath been provided for the emperor's own table."†

This catalogue, were it necessary, might easily be extended; but it may be sufficient, in addition, to remark that almost every shore has some species peculiar to it, or more plentiful than elsewhere, which the natives make subservient to the table. Thus, at Bourdeaux, the Anomia undulata is considered a delicacy; while, on some parts of the shores of

ment to the poor of the neighbouring district. Besides the home consumption, it is computed that 300*l.* is annually gained in Greatham by this occupation."—*Surtees's Hist. of Durham*, iii. 941.

* Turton's Conch. Brit. 183.

† Hist. of Japan, i. 140.—The text is perhaps already too overloaded with particulars, and for this reason I add in a note the few following from a more copious collection:—Adanson praises his Apan, a species of Pinna, for the excellence of its fish; but his Lunot, a species of Pullastra, is the sweetest and most delicate of all the Senegal shell-fish.—*Voy. au Sénég.* 213, 228. Osbeck says that in China the animal of Conus chinensis is put into water, and sold in every street by the name of Ha-in-yo.—*Voy. to China*, 1. 203. A species of Volute, the Yet of Adanson, whose animal sometimes weighs five or six pounds, is smoked and preserved by the negroes of Senegal against times of famine, to which they are frequently exposed.—Some of the larger Chitons are eagerly devoured by the lower orders in the West Indies, who have the folly to call them beef: the thick fleshy foot is cut away from the living animal, and swallowed raw, while the viscera are rejected.—*Zool. Journ.* v. 30. Of the Unio margaritiferus, or pearl-mussel, Boetius says: "Such is their estimation among the deintiest kinds of food, that they were not unworthilie called, of old time, widowes' lustes."—*Scot.* 15. See also the article "Mollusca" in Supp. Encycl. Brit.

the Mediterranean, the rocks are broken with large hammers in order to procure the Lithodomus dactylus, or Seadates, which abound there, and are admired even at the tables of the luxurious,—the fish proving all the more delicious, says Aldrovandus, that it is fed not with gross sea-water, but with a certain most limpid dew which filters through the rocks.* In India, the favourite dish bacassan, extolled by Rumphius as the most grateful of all kinds of food,† is prepared from the Tellina gari, Linn.; and in South America they use a large mussel, eight inches long, and of excellent flavour, but the name of which is unknown to me. "They are often salted and dried; after which, they are strung on slender rushes, and, in this manner, large quantities are exported."‡ This practice reminds me of a somewhat similar one adopted by the Africans in the neighbourhood of the river Zaire or Congo. They take large quantities of a species of Mya from out the mud round Kampenzey Island, and, as in a raw state the animals are without flavour, they stick them on wooden skewers, as the French do frogs, and half dry them. They pass thus into a state of semi-putrefaction, become entirely to the taste of the negroes, and form an important object of traffic.§ The natives of New Holland and New Zealand did, at the time of their discovery, use the Chama gigas, or "Dutchman's Cockle" (Fig. 5, *c*), a very large shell, a pair of the valves of which were presented, as natural curiosities, to Francis I. by the Venetians; and which Louis XV., more zealous, as he has himself taken care to let us know, for the glory of God, destined to hold holy water in the magnificent church of St. Sulpice in Paris, where they to this day actually serve the purpose of baptismal fonts.‖ Captain Cook tells us that it sometimes attains a size so great that two men are required to carry it; and containing full 20 lbs. of good meat, it often furnished him and his fellow-adventurers an esteemed repast.¶ Bruce mentions the same species as being

* See also Strickland in Charlesw. Mag. N. Hist. i. 23.

† Baster Opusc. Subs. ii. 76.

‡ Stevenson's Narrative of Twenty Years' Residence in South America, i. 123.

§ Tuckey's Narrative, &c. 55.

‖ Smith's Tour on the Continent, i. 82.

¶ Answers returned by Sir Philiberto Vernatti, resident in Batavia, in Java Major, to certain inquiries sent thither by order of the Royal Society: Question put—"Whether, about Java, there be oysters of that vast bigness as to weigh three hundredweight?" Answ.—"I have seen a shell-fish, but nothing like an oyster, of such a bigness, the fish being salted and kept in pickle, afterwards boyled, tasteth like brawn in England, and is of an horney substance."—*Sprat's Hist. R. Soc.* 171.

found in the Red Sea, but in this respect he is probably mistaken. The fish of *his* shell, however, are very wholesome, and have a peppery taste, a circumstance so much the more convenient, that they carry that ingredient of spice along with them for sauce, with which travellers seldom burthen themselves.*

Of the marine Gasteropods I have not much to say. You may have noticed the periwinkle (Littorina littorea, Fig. 6, *a*) and common whelk (Buccinum undatum) exposed for sale, in large quantities, in the fish-shops of the metropolis;† and they frequently furnish to the poorer classes of our sea-coast towns and villages a repast, perhaps sufficiently wholesome, and certainly not destitute of relish.‡ Holinshed is careful to enumerate them among our native productions:—"We have in like sort no small store of great whelkes, scalops, and periwinkles, and each of them brought farre into the land from the sea-coast in their several seasons;"§ and in the following more complete list of our native edible mollusca, Drayton assigns to each its popular virtue:—

"The oyster hot as they, the musle often trim'd
With orient pearls within, as thereby nature show'd,
That she some secret good had on that shell bestow'd.
The scallop cordial judg'd, the dainty whilk and limp,
The periwincle, prawn, the cockle, and the shrimp,
For wanton women's taste or for weak stomachs bought."

You are ready to exclaim Enough! but let me plead, in excuse of my prolixity, that the subject was deemed of such importance by the Dutch Society of Science of Haarlem, that they offered a prize to any one who should add to the list of the mollusca in common use any others that could with advantage be employed as wholesome or agreeable food; and though to us—even the poorest—they may be properly looked upon as mere entremets which can easily be dispensed with, it is far otherwise with the still poorer inhabitants of several of the western isles of Scotland. Periwinkles and Limpets (Patella vulgata, Fig. 6, *b*), which so profusely stud the rocks of their shores, are their daily fare, and on which they are sometimes reduced to the necessity of altogether

* Bruce's Travels, ii. 112.

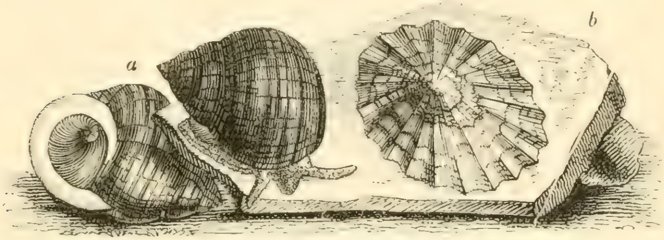
† They do not appear to have been so common in the days of Samuel Johnson. In his "Journey to the Western Islands," he says, "Here I saw what I had never seen before,—limpets and mussels in their natural state."—p. 295.

‡ In the lively old song, "The Blythsome Bridal," buckies and welks are enumerated among the dishes of the heterogeneous feast.

§ Desc. of England, 225.

subsisting. In the Isle of Skye, for example, we are told that there is almost annually a degree of famine, when the poor are left to Providence's care, and prowl, like other animals, along the shores, to pick up limpets and other shell-fish,—"the casual repast," adds Mr. Pennant, from whom I have borrowed this melancholy account, "of hundreds, during part of the year, in these unhappy islands."*

Fig. 6.



The case is now, I trust, much altered for the better; but still it is occasionally bad enough. Dr. Macculloch, in his account of the Highlands and Western Islands published in 1824, says—"Where the river meets the sea at Tongue there is a considerable ebb, and the long sand-banks are productive of cockles in an abundance which is almost unexampled. At that time (a year of scarcity), they presented every day at low water a singular spectacle, being crowded with men, women, and children, who were busily employed in digging for these shell-fish as long as the tide permitted. It was not unusual also to see thirty or forty horses from the surrounding country, which had been brought down for the purpose of carrying away loads of them to distances of many miles. This was a well-known season of scarcity, and, without this resource, I believe it is not too much to say that many individuals must have died of want."†

* Tour in Scotland and Voyage to the Hebrides, 1772. See also a painful and truly affecting statement by Mr. Patterson "On the Common Limpet considered as an Article of Food in the North of Ireland," in Ann. Nat. Hist. iii. 231. Mr. Patterson has abridged this paper in his Zoology for Schools, 171-2. "The inhabitants of the rest of the Orcades despise those of Swona for eating limpets, as being the last of human meannesses."—*Life of Sir W. Scott*, iii. 191.

† Vol. iii. 349.—The island of Barra has been long famous for its cockles. "This ile," says Dean Monro, "is full of grate cokills, and alledgit by the ancient countrymen that the same cokills comes down out of the foresaid hill through the said strype, in the first small forme that we have spoken of, and after ther coming down to the sandes growis grate cokills always. Ther

It is the same with many savage nations. They either habitually live on mollusca, which afford them their main supply, or they resort to them when the fruit season has past, or when the trees have failed in their usual productiveness. Thus from the particulars scattered through the relations of Cook, Freycinet, and Beechy, the conclusion is forced upon us that the natives of Australia derive their principal subsistence from this source. Wherever marks of fire were observed there the shells of oysters, cockles, mussels, and various other bivalves, robbed of their contents, were strewed around, and sometimes in numbers scarcely credible. They apparently eat none of them in a raw state, nor do they always go on shore to dress them, for they have frequently fires in their canoes for that purpose. "In California," says Captain Beechy, "mussels are found in considerable quantities upon the shores, and form a large portion of the food of the Indians bordering upon the coasts and rivers. At Monterey two species of Haliotis of large size are also extremely abundant, and equally sought after by the Indians. They are found on the granite rocks forming the south-east part of the bay, which appears to be their northern limit. The natives make use of these shells for ornaments, and decorate their baskets with pieces of them."* To the people of Terra del Fuego shell-fish are every thing. Captain Cook saw no appearance of their having any other food; "for, though seals were frequently seen near the shore, they seemed to have no implements for taking them. The shell-fish are collected by the women, whose business it seems to be to attend, at low water, with a basket in one hand, a stick pointed and barbed in the other, and a satchel

is no fairer and more profitable sands for cokills in all the world.' The cokills still preserve their good character, and, unlike many good things, appear to have conducted themselves peaceably, according to the laws which regulate the increase of a thriving population." "It is not easy to calculate," says Mr. Wilson, "the amount of such beds of shell-fish, but we may mention that, during a period of great distress which prevailed a good many years ago, all the families in the island (then about two hundred in number) resorted, for the sake of this food, to the great sands at the northern end of Barra. It was computed that, for a couple of summers at the time alluded to, no less than from one hundred to two hundred horse-loads were taken at low water every day of the spring-tides during the months of May, June, July, and August. We were pleased to hear it observed that the shell-fish are always most abundant in years of scarcity."—*Voy. round the Coasts of Scotland*, i. 460.—In North Uist, cockles of equal size and most delicate flavour are found abundantly, and afford an unfailing source of food to the people.—*Ibid.* i. 445.

* Voy. to the Pacific, &c., ii. 83. See also p. 74, and vol. i. 33: and Home's Lect. on Comp. Anat. v. 358. Haliotis tuberculata is commonly eaten in Guernsey and Jersey.

at their backs: they loosen the limpets and other fish that adhere to the rocks with the stick, and put them into the basket, which, when full, they empty into the satchel." * The Japanese even, though a civilized nation, appear to make such a considerable use of shell-fish that they may be reckoned among their necessaries. "All sorts of oysters, mussels, and shells, of which there is a great plenty and surprising variety in the Japanese seas, are eat, none excepted, raw, pickled, salted, boiled, or fried. They are daily gathered on the coasts in low water. Divers dive for them to a considerable depth. Others fish them with nets." One the most esteemed is the Haliotis or Awabi, probably the same as those mentioned by Beechy, of which Kæmpfer gives the following account:—"They lie deep under water, sticking fast to rocks, or to the bottom of the sea, from whence they are taken up by fishermen's wives, they being the best divers of the country. They go down armed with darts, or long knives, to defend themselves against Kayes and Porpesses; and when they see an Awabi they pull it off suddenly before the animal is aware, because otherwise it would fasten itself to the rocks or the bottom of the sea so strongly that no force would be strong enough to tear it off. This shell is filled with a large piece of flesh of a yellowish or whitish colour, and a very tough substance, though without fibres. They say it was the common food of their necessitous ancestors, in memory whereof when they entertain company, they always provide a dish of it. It is also become a custom with them, as well among the vulgar as people of quality, that when they send one another presents of money, cloth, stuffs, fruits, or any thing else, a string, or at least, a small bit of the dried flesh of this shell is sent along with them as a good omen, and in order to put them in mind of the indigence of their forefathers. The flesh is cut into thin slices or strings, which are extended on a board and dried." †

Of the Cephalopods several species are edible and are used for food in the maritime parts of Italy, France, Greece, and other countries of southern Europe, epicures selecting those kinds that are distinguished for their tenderness and sapidity.

* See also Voy. of Advent. and Beagle, iii. 234.

† Hist. of Japan, i. 139. I cannot make out what the "Clacas" of the island of Teneriffe is. They are affirmed to be "absolutely the very best shell-fish in the world." "They grow in the rocks five or six under one great shell, through the top holes whereof they peep out with their nebs, from whence (the shells being broken a little more open with a stone) they draw them forth."—*Sprat's Hist. R. Soc.* p. 208.

For example, the Loligo vulgaris affords at all seasons a tender and delicate dish, while the meat of L. saggittata is always tough and acid, and not presentable at fashionable tables. Some species of every genus was a favourite article of food with the old Greeks and Romans, probably from a current belief that the meat possessed aphrodisiac qualities. At the nuptial feast of Iphicrates, who married the daughter of Cotys, king of Thrace, a hundred polypi and sepiæ were served up. The Greek epicures prized them most when they were in a pregnant condition, and had them cooked with high sauces; while the hardy Lacedæmonian boiled the animals entire, and was not disgusted with the black broth formed by their inky liquor diffusing itself in the water. The Octopus or Polypus was held in highest estimation. The "good old story" of Philoxenus may be quoted in illustration:—

> "Of all fish-eaters
> None sure excell'd the lyric bard Philoxenus.
> 'Twas a prodigious twist! At Syracuse
> Fate threw him on the fish call'd 'Many-feet.'
> He purchas'd it and drest it; and the whole,
> Bate me the head, form'd but a single swallow.
> A crudity ensued—the doctor came,
> And the first glance inform'd him things went wrong.
> And 'Friend,' quoth he, 'if thou hast aught to set
> In order, to it straight;—pass but seven hours,
> And thou and life must take a long farewell.'
> 'I've nought to do,' replied the bard: 'all's right
> And tight about me. . . . .
> . . . . I were loath, howe'er,
> To troop with less than all my gear about me;—
> Good doctor, be my helper then to what
> Remains of that same blessed Many-feet.'" *

The Loligo or Teuthis, served up with fat and green sauce, was only less esteemed. Thus we find in the Acharnians of Aristophanes a ludicrous curse against Antimachus, v. 1156: "Oh! may I see him longing for sleeve-fish, and just as it lands hissing hot from the fire, and he is about to fall to, may a dog snatch it away from him." And of the

* See Quart. Rev. xxiii. 260, where the story is told at greater length. We need scarcely say that from it is borrowed the well-known lines in Pope:—

> "A salmon's belly, Helluo, was thy fate:
> The Doctor call'd, declares all help too late.
> 'Mercy (cries Helluo) mercy on my soul!
> Is there no hope? alas!—then bring the jowl.'"

Diogenes, the cynic, died of eating a polypus raw. Upon which Aldrovandus remarks: "We shall be mad if we would imitate him withholding all preparation."

Sepia we have it recorded that its flesh is tender and pleasant and digestible, and good also for the bowels. Alexis, a comic writer, describes the proper mode of dressing it. The cook says, "I will chop off the legs and fins of some of them to boil; and having cut up the rest of the body into many small squares, and rubbed them with a little salt, while the guests are at supper, I will serve them up hissing hot in the fryingpan."* I suspect that even these luscious details may not overcome your English repugnance to feed upon such a bizarre and ugly class of animals, although I have been assured by some venturesome experimentalists that our native exemplars make a good soup, and are very palatable in a more solid form. Of Loligo vulgaris, Mr. Couch attests that they are "excellent food, bearing a considerable resemblance to tripe;" and this he says of those that frequent the shores of Cornwall.† By most eastern nations their indigenous Cephalopods are esteemed: they may be seen exposed for sale in the bazaars throughout India,‡ in China, and in Japan; and a kind of Octopus furnishes the Japanese with "a common Soccano or side dish," which is eaten either fresh, boiled, or pickled.§

The Tunicata are to all outward appearance very unfit for the table; and I know but one of the class in which man has sought to indulge his caprice. This is the Piuri of South America, which is eaten either roasted or boiled, and has a taste similar to that of the lobster. Great quantities are annually dried for exportation; and in the interior it brings a great price, being considered a very powerful stimulant. The outer skin is coriaceous, and divided into separate cells by means of strong membranes: in each of these, in a detached state, is formed the Piuri. It is about the size of a large cherry, which it much resembles in colour.||

The list of the terrestrial culinary species is a little, and only a little, more extensive. Several species of snails (Helix) are eaten, of which Draparnaud says, the H. naticoides is most tender and delicate, the best tasted and

* The student will find all that the ancients have written of edible cuttlefish in Aldrovandus, Opera, v. 38.

† Cornish Fauna. 82. Mr. Couch's comparison reminds us of the origin of the English name, Cuttlefish. **Kuttel**, in German, signifies tripe; and the resemblance of the Octopus to tripe is obvious. **Kuttelfisch**, **Bleckfisch**, **Meer-spinne** (Sea-spider), and **Polkuttel**, are the German names of the Cephalopods.

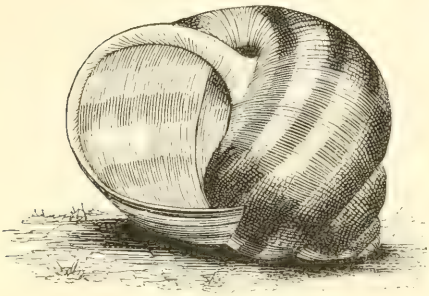
‡ Bennett's Wand. New S. Wales, i. 344.

§ Kæmpfer's Japan, i. 137.

|| Stevenson's South America, i. 124.

most digestible of all, but the H. pomatia (Fig. 7), is the best known and most commonly found in the market.* The Romans took great pains in rearing these snails, which that luxurious people were wont to indulge in, not from any peculiar relish for such tasteless food, but from a belief in their aphrodisiaical virtue, deduced, as Lister conjectures, from a knowledge of the seat of their reproductive organs. † The snails were kept in sties called cochlearia, ‡ "and those had their distinct partitions, for sundry sorts of them: that the white, which came from the parts about Reate, should be kept apart by themselves: the Illyrian (and those were chiefe for greatnesse), alone by their selves: the Africans (which were most fruitful), in one several: and the Solitanes (simply the best of all the rest) in another. Nay more than that, he had a devise in his head to feed them fat, namely, with a certain paste made of cuit and wheat meale, and many other such like: to the end forsooth, that the glutton's table might be served plentifully with home-fed and franked great winkles also. And in time, men grew to take such a pride and glory in this artificial feat, and namely, in striving who should have the biggest, that in the end one of their shels ordinarily would containe eighty measures called Quadrants, if M. Varro say true, who is mine author."§ You need no longer hold up to imitation the temperance of the younger Pliny, whose supper consisted of only three snails, two eggs, a barley-cake, a lettuce, sweet wine, and snow; but, alas! participating in that degeneracy which is

Fig. 7.



* Philippi mentions Helix naticoides, H. aspersa and H. vermiculata, as forming articles of common food in Sicily. Enum. Mollusc. Sicil. p. 126.

† Lister in Phil. Trans. an. 1669, p. 1013. Exer. Anat. de Coch. 146. Hist. Anim. Ang. 112.

‡ The cochlearia were invented by Fulvius Hirpinus, a little before the civil war with Pompey the Great.—*Plin. Hist. Nat.* lib. ix. cap. 82.

§ Holland's Plinie, i. 267. Cuvier Hist. des. Sc. Nat. i. 227. The large species is presumed to have been the Achatina perdrix of Lamarck, a native of Africa.

"Stewed shrimps and *Afric cockles* shall excite
A jaded drinker's languid appetite."—Horace.

said to characterise the human race of the present day, no snail now ever attains a bulk at all comparable to those of Varro. Snails, however, are still eaten in great numbers on the continent of Europe, and they are preferred when taken directly from their hybernating quarters. In Switzerland, where there are gardens in which they are fed in many thousands together, a considerable trade is carried on in them about the season of Lent; and at Vienna, a few years ago, seven of them were charged at an inn the same as a plate of veal or beef. The usual modes of preparing them for the table are, either boiling, frying them in butter, or sometimes stuffing them with farce-meat; but in what manner soever they are dressed, it is said, their sliminess always, in a great measure, remains. Those edible snails were introduced into England, about the middle of the sixteenth century, by Charles Howard, of the Arundel family; and afterwards by the eccentric Sir Kenelm Digby, either as being a favourite foreign delicacy, or in order to cure his wife, (Venetia Anastasia, daughter of Edward Stanley, and celebrated for her beauty,) of a consumptive disease,* for they had a high reputation for their restorative virtues. The fashion seems to have taken, for the great master-cook, Robert May, has left several recipes for dressing snails among the secrets of his fifty years' experience; † but, like other fashions, it soon passed away, for the English have no relish of such "liquorish viands." ‡ In proof of this, and as a pleasant conclusion to a long letter, allow me to transcribe for you a story from the pen of Sir Walter Scott:—

"The chemical philosophers Dr. Black and Dr. Hutton were particular friends, though there was something extremely opposite in their external appearance and manner. Dr. Black spoke with the English pronunciation, with punctillious accuracy of expression, both in point of matter and manner. The geologist was the very reverse of this: his conversation was conducted in broad phrases, expressed with

* See on this point Turton's Manual, p. 47. Some years ago they were introduced into Scotland by Dr. Neill, and placed in his curious and most interesting garden at Cannonmills; but, we believe, they have not prospered, and are gradually disappearing, or have died out.

† The above particulars are from the works of Pennant, Bingley, &c.; and from Southey's Omniana, ii. 81.

‡ "En France, les Escargots n'ont qu'une réputation de caprice; on en mange, il est vrai, dans quelques-uns de nos départements méridionaux, et c'est une des ressources des malheureux. S'il existe quelques amateurs qui les recherchent, il faut dire à leur justification, et pour me servir d'une expression vulgaire, que la sauce leur fait manger le poisson."—*Chenu Leç. Element. p.* 156.

a broad Scotch accent, which often heightened the humour of what he said.

"It chanced that the two doctors had held some discourse together upon the folly of abstaining from feeding on the testaceous creatures of the land, while those of the sea were considered as delicacies. Wherefore not eat snails? They are well-known to be nutritious and wholesome, even sanative in some cases. The epicures of olden times enumerated among the richest and raciest delicacies the snails which were fed in the marble quarries of Lucca: the Italians still hold them in esteem: in short, it was determined that a gastronomic experiment should be made at the expense of the snails. The snails were procured, dieted for a time, then stewed for the benefit of the two philosophers; who had either invited no guest to their banquet, or found none who relished in prospect the *piéce de resistance.* A huge dish of snails was placed before them: but philosophers are but men, after all; and the stomachs of both the doctors began to revolt against the proposed experiment. Nevertheless, if they looked with disgust on the snails, they retained their awe for each other: so that each, conceiving the symptoms of internal revolt peculiar to himself, began, with infinite exertion, to swallow, in very small quantities, the mess which he internally loathed. Dr. Black at length 'shewed the white feather,' but in a very delicate manner, as if to sound the opinion of his messmate. 'Doctor,' he said, in his precise and quiet manner, 'Doctor,—do you not think that they taste a little—a very little, green?' 'D—d green, d—d green, indeed,—tak' them awa', tak' them awa',' vociferated Dr. Hutton, starting up from table, and giving full vent to his feelings of abhorrence. And so ended all hopes of introducing snails into the modern *cuisine;* and thus philosophy can no more cure a nausea than honour can set a broken limb." *

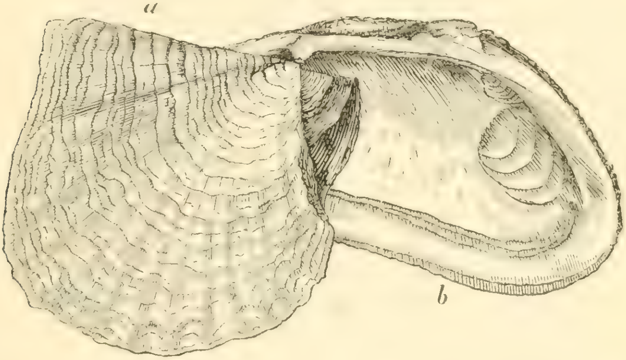
* Quart. Review xxxvi. 197.

LETTER IV.

THE MOLLUSCA CONSIDERED IN THEIR RELATIONS TO MAN.

The only mollusk which rivals the oyster in the relation of its utility to man is the Pearl-Oyster (Meleagrina margaritifera,* Fig. 8, *a*), the parent of the highly-prized ornaments from which the shell derives its specific name. Pliny intro-

Fig. 8.



duces his account of these in this fashion :—" It was not sufficient belike to bring the seas into the kitchen, to let them down the throat into the belly, unlesse men and women both carried them about in their hands and eares, upon their head, and all over their body. And yet what societie and affinitie is there betwixt the sea and apparell? what proportion betwixt the waves and surging billows thereof, and wooll? for surely this element naturally receives us not into her bosom unlesse we be stark naked; and set the case there were so great good fellowship with it and our bellies, how comes our backe and sides to be acquainted with it? But wee were not contented to feed with the peril of so many men, unlesse we

* Mr. Templeton states that the Pearl-Oyster of Ceylon is the Avicula radiata of Leach (Ann. and Mag. N. Hist. xi. 325); but this shell is considered by Lamarck to be merely a variety of the Meleagina.

be clad and araied also therewith. O, the folly of us men! see how there is nothing that goeth to the pampering and trimming of this our carcasse, of so great price and account, that is not bought with the utmost hazard, and costeth not the venture of a man's life." The eloquence of the original philippic is somewhat sobered down in the translation of the worthy Philemon Holland, and perhaps the almost incredible extravagance of Roman vanity in the use of these ornaments might justify the naturalist's warmth. "Our dames," he continues in a subsequent passage, "take a great pride in a braverie, to have these not only dangling at their fingers, but also two or three of them together pendant at their eares.* And names they have for-sooth newly devised for them, when they serve their turne in this their wanton excesse and superfluitie of riot: for when they knocke one against another as they hang at their eares or fingers, they call them Crotalia, *i.* Cymbals: as if they tooke delight to heare the sound of their pearles ratling together. Now adayes also it is growne to this passe, that meane women and poore men's wives affect to wear them, because they would be thought rich: and a by-word it is amongst them, That a faire pearle at a woman's eare is as good in the street where she goeth as an huisher to make way, for that every one will give such the place. Nay, our gentlewomen are come now to weare them upon their feet, and not at their shoo latchets only, but also upon their startops and fine buskins, which they garnish all over with pearle. For it will not suffice nor serve their turne to carie pearles about them, but they must tread upon pearles, goe among pearles, and walke as it were on a pavement of pearles." After this general statement, Pliny draws in detail a portrait of one of these dames, which is curious enough to deserve quotation:—"I myselfe have seen Lollia Paulina (late wife, and after widdow, to Caius Caligula the emperor) when she was dressed and set out, not in stately wise, nor of purpose for some great solemnity, but only when she was to go to a wedding supper, or rather unto a feast when the assurance was made, and great persons they were not that made the said feast: I have seen her, I say, so beset and bedeckt all over with hemeraulds and pearles, disposed in rows, ranks, and courses one by another: round about the attire of her head, her cawle, her borders, her peruk of hair, her bond grace and chaplet; at her eares pendant, about her neck in a carcanet, upon her wrest in bracelets, and on her fingers in

* "——— Her (Rome) women wear
The spoils of nations in an ear,
Changed for the treasure of a shell."—*Chorus in "Catiline."*

rings; that she glittered and shon again like the sun as she went. The value of these ornaments she esteemed and rated at four hundred thousand sestertii, and offered openly to prove it out of hand by her bookes of accounts and reckonings. Yet were not these jewels the gifts and presents of the prodigall prince her husband, but the goods and ornaments from her owne house, fallen to her by way of inheritance from her grandfather, which he had gotten together even by the robbing and spoiling of whole provinces. See what the issue and end was of these extortions and outrageous exactions of his: this was it, That M. Lollius, slandered and defamed for receiving bribes and presents of the kings in the east: and being out of favour with C. Cæsar, sonne of Augustus, and having lost his amitie, dranke a cup of poison, and prevented his judiciall triall: that forsooth his neece Lollia, all to be hanged with jewels of four hundred thousand sestertii, should be seene glittering, and looked at of every man by candle-light all a supper time."—Still greater examples even than Lollia's of this "excessive riot and prodigalitie" can be instanced. Julius Cæsar presented Servillia, the mother of M. Brutus, with a pearl worth 48,417*l*. Cleopatra, "in the height of her pride and wanton brauverie," at a supper with Antony, of which Pliny has given an interesting account, took from her ear one of two pearls, of the value of 80,729*l*. 3*s*. 4*d*., "the singular and only jewels of the world, and even nature's wonder," dissolved it in vinegar, and swallowed the precious potion;* and its fellow would have gone to make another draught, had this celebrated queen not been prevented in her folly, which we find was imitated and exceeded by Cladius, son of Æsop the tragedian poet. These were the freaks of pure wantonness with which the satirist may amuse himself: but even against the moderated luxury of following and of the present times, there never have been wanting puling pseudo-moralists to declaim in the same style, forgetting, in their cynical humour, that the pride which leads us to adorn our persons is a passion of universal prevalence among mankind,—an inherent part of our mental constitution which contributes, when kept within certain limits, not little to our moral good. Of these vilifiers of the fair sex in particular, Father Bonanni is not less invective than Pliny, though by much less eloquent. After indulging in some details scarcely befitting a holy monk, he exclaims: —"Heu monstrosa vanitatis fœmineæ deliramenta! Quæ

* Sir Wm. Capell, in proof of loyalty we presume, emulated this expensive frolic when he drank "a dissolved pearl (which cost him many hundreds) in a health to the king," Henry VII.—*Fuller's Worthies*, iii. 190.

concharum excrementis superbiunt, pulchrioresque se credunt:" and denouncing this perilous vanity, the wily priest holds up to all praise and worthy imitation such pious ladies as consecrate their pearls to adorn the images of the saints and their altars! "Quam verò sanius utuntur margaritis præclaræ illæ mulieres, a quibus in templis altaria, sacræque imagines eisdem decorantur."*

From the earliest times of which we have any record, the orient pearl has been the object of commerce, and, from its peculiar beauty and splendour, has held in all ages and with all people, civilized or barbarian, a place among the precious gems only inferior to the diamond. The Phenicians brought pearls from the east, which continues to this day to furnish the most valuable and principal supply. The greatest plenty of them, according to Pliny, were found on the coast of Taprobane or Ceylon, and Stoidis, and about Perimula, a promontory and city of India, "but the most perfect and exquisite of all others be they that are gotten about Arabia, within the Persian gulfe." This statement remains in general applicable enough. In the Persian gulf, the isles of Baharein, or Bahrein, retain their fame for their pearl-fishery, the value of which, in the sixteenth century, was estimated at a produce of 500,000 ducats.† The pearls are said to be harder but less brilliant than those of Ceylon; while the fishery of Kharrek, in the same gulf, produces them of a larger size, but deficient in whiteness and regularity. We find beds of the pearl-oyster widely diffused in the gulfs of the Indian ocean, and on the shores of its large islands, at the Sooloo or Suluk islands, and on the shores of Japan, Sumatra, China, Java, and Borneo; and near Cape Comorin, probably the Perimula of Pliny, there is a fishery, now under the superintendance of the British, the net revenue of which, in 1807, was 81,917 star-pagodas. All these are, however, very inferior in value and extent to the celebrated fishery on the western shores of Ceylon.

* Rec. Ment. et Ocul. 80. A matter-of-fact physician raves in the same strain:—"Did our fair countrywomen consider at what an expense of human life and human health those pearly decorations are procured with which they encircle their necks and bosoms, they would cast them off, and commit them to the ocean from whence they were dragged! To encourage that horrible fishery is to league themselves with sharks, and degrade human nature *beneath* the level of the brute creation, for the animal only seeks his prey to satisfy the cravings of his appetite!"—*J. Johnson's Medico-Chirurg. Q. Journ.* ii. No. 5.

† "At Bahrein alone, the annual amount produced by the pearl-fishery may be reckoned at from 200,000*l.* to 240,000*l.*"—Dr. Baird *in Chambers's Miscellany,* No. 167, p. 21.

The banks,* which extend several miles along the coast, are fourteen in number, and are divided into three or four portions, each fished in succession; a repose of three or four years being thus given to the oysters to grow and propagate. Previously to their being let or farmed (for our government sell by auction the privilege of fishing on them), the banks are carefully surveyed and the condition of the oysters ascertained; and if a sale is agreed upon, the merchant is permitted to fish them for only six or eight weeks, the actual number of fishing-days being reduced to about thirty, from the interruptions occasioned by the holidays observed by the divers of different sects and nations, and by the unlucky days foretold by their conjurors, a certain number of whom the divers keep in their pay to foretel seasons and to frighten away sharks.

The fishery always begins in the month of April, because in those latitudes the sea is then at its calmest state, and it is generally continued until the middle or end of May. During its continuance, there is no spectacle which Ceylon affords more striking to a European than the Bay of Condeatchy. "This desert and barren spot is at that time," says an eye-witness, "converted into a scene which exceeds in novelty and variety almost any thing I ever witnessed. Several thousands of people, of different colours, countries, casts, and occupations, continually passing and repassing in a busy crowd; the vast numbers of small tents and huts erected on the shore, with the bazaar or market-place before each; the multitude of boats returning in the afternoon from the pearl banks, some of them laden with riches; the anxious expecting countenances of the boat-owners, while the boats are approaching the shore, and the eagerness and avidity with which they run to them when arrived, in hopes of a rich cargo; the vast numbers of jewellers, brokers, merchants, of all colours and all descriptions, both natives and foreigners, who are occupied in some way or other with the pearls, some separating and assorting them, others weighing and ascertaining their number and value, while others are hawking them about, or drilling and boring them for future use: all these circumstances tend to impress the mind with the value and importance of that object which can of itself create this scene." From another intelligent observer we learn that, "It not only attracts a multitude of Cingalese,

* The term "bank" means no more than the spot on which the oysters grow, which may not be nearer the surface than the surrounding parts, excepting by the diminution of depth caused by the quantity of oysters. Their average depth is twelve fathoms.

or natives of the island, to the coast, but crowds of speculators from all parts of the vast Indian peninsula, whose variety of language, manners, and dress is described as being very striking and pleasing. The temporary abodes erected by them, or for them, are also curious and picturesque. On a solitary sea-shore a mass of almost innumerable huts is at once seen to arise on the eve of the fishery. These huts are merely composed of a few poles stuck in the ground, interwoven with light bamboos, and covered with the leaves of the cocoa-nut tree; "yet," says M. de Noe, "these ephemeral habitations often shelter as many as one hundred and fifty thousand persons." *

The ancients had also pearl-fisheries in the Red Sea, but they are now either exhausted or neglected, and cities of the greatest celebrity have in consequence sunk into insignificance or total ruin. Dahalac was the chief port of the pearl-trade on the southern part of the Red Sea, and Suakem on the north; and under the Ptolemies, or even long after, in the time of the caliphs, these were islands whose merchants were princes: but their bustle and glory have long since departed, and they are now thinly inhabited by a race of miserable fishermen.† In the Mediterranean, pearls were procured from the Straits of Bosphorus near Constantinople, from Actium in Acarnania, and "in our seas of Italie," probably in the latter case taken from the shell of the Pinna, but the pearls were never held in much esteem, and the fisheries appear to have been early forsaken. I have also to recall to your memory the fact related by some historians of good authority, that the early fame which Britain had acquired for her fertility in these gems was the main inducement of Cæsar to invade its shores; "the onelie desire of them caused Cæsar," to adopt the words of Holinshed, "to adventure hither, after he had seene the quantities and heard of our plentie of them, while he abode in France, and whereof he made a taberd which he offered up in Rome to Venus, where it hung long after as a rich and notable oblation and testimonie of the riches of our countrie." ‡ The historian's

* See Sprat's Hist. Roy. Soc. 169; Percival's Ceylon; Malté Brun's Geography, iii. 227; and Penny Magazine, 1833, 174. Bishop Heber says, "The pearl-fishery was at one time very productive, but some years ago it entirely failed, and though it has lately been resumed, the success has been small."—*Journal* iii. 146, 8vo.

† Bruce's Travels in Abyssinia, ii. 246—249.

‡ Desc. of England, 239. Browne has versified the story in the following

"———— She wept, ————
———————————— the fair Neriades,

inference may at least be questioned, for truly British pearls are in general dim of colour and of inferior size, so that we possibly break no law of charity in suspecting that the votive offering of the great soldier might have been withheld had it been of higher value. Our earlier historians indeed, and the Scottish especially, are very unwilling to admit this inferiority; which, nevertheless, is certain as regards the present produce, and Pliny's authority is enough to satisfy us that it was so of old.* Boetius says, "The perles that are so gotten in Scotland are not of small value; they are verie orient and bright, light and round, and sometimes of the quantitie of the naile of one's little finger, as I have had and seene by mine owne experience."† Similar is the language of Bishop Leslie;‡ and there can be no question that many good specimens were occasionally gotten among the heap of inferior kinds, which were good for nothing but to be ground down for the use of the apothecary, pearl-powder being at that day reckoned a sovereign remedy in many diseases. The learned Cardan tells us that he had seen on the head of a girl in Edinburgh a chaplet formed of about seventy Scottish pearls, all equal in size and remarkable for their beauty.§ There is now, according to the minister of the parish of Cargill, in Perthshire, in the custody of the Hon. Mrs. Drummond, of Perth, a pearl necklace, which has been in the possession of the ladies of that noble family for several generations, the pearls of which were found in the Tay, and for size and shape are not to be equalled by any thing of the kind in Britain.|| A

They came on shore, and slyly as they fell,
Convey'd each tear into an oyster-shell,
And by some power that did affect the girls,
Transform'd those liquid drops to orient pearls,
And strew'd them on the shore; for whose rich prize
In winged pines the Roman colonies
Flung through the deep abyss to our white rocks
For gems to deck their ladies' golden locks."

* Cuvier says that Elien is the first author who mentions the British pearls, (Hist. des. Sc. Nat., i. 298,) but his annotator reminds us that they had been mentioned by Pliny. The imperial diadem of the sovereigns of the ancient Britons was sometimes encircled with an ornament of the mussel-pearls, as appears from the coins which have come down to us.—*Whitaker's Manchester*, i. 22, 342.

† Hist. of Scot., 15.

‡ "At vero margaritarum et copia et pretium magnum est: splendescentem ipsæ candorem referunt, sed iis tamen quæ ex oriente importantur paulo obscuriores. Nascuntur non minus in conchis fluvialibus esui quidem illis ineptis, quam marinis."—*De Orig. Scot.* 15.

§ Aldrov. Op. v. 424.

|| Stat. Ac. of Sotland, xiii. 532. This is probably the necklace mentioned by Sir Robert Sibbald,—"Ipse verò vidi corollam ex margaritis Scoticis, quæ bis mille coronatis æstimabatur: erant enim grandiores pisis, exactè rotundæ, nitidissimi candoris."—*Nat. Hist. Scot.* iii. 27.

notion prevails that Sir Richard Wynn, of Gwydir, chamberlain to Catherine, Queen of Charles II., presented her Majesty with a pearl taken in the Conway, which is to this day honoured with a place in the regal crown.* Sir Robert Redding, in 1693, sent to the Royal Society a pearl-mussel from Ireland which yielded a pearl that was sold for twelve pounds, a large sum, when you consider that this was nearly one hundred and fifty years ago. The same Sir Robert, when in Ireland, "saw one pearl bought for fifty shillings, that weighed thirty-six carats, and was valued at 40*l.*, and had it been as clear as some others produced therewith, would certainly have been very valuable. Everybody," he continues, "abounds with stories of the good pennyworths of the country, but I will add but one more: a miller took out a pearl, which he sold for 4*l.* 10*s.* to a man that sold it for 10*l.*, who sold it to the late Lady Glenanly for 30*l.*, with whom I saw it in a necklace; she refused 80*l.* for it from the late Duchess of Ormond."†

The British pearls, as you will have noticed, are generated in the fresh-water mussel (Unio margaritiferus, Fig. 8, *b*), which lives in cold rapid rivers. In Wales, the Conway has been long celebrated for them,—

> "Whose pretious orient pearls that breedeth in her sand,
> Above the other floods of Britain doth her grace;"

and the fishery still exists; though, according to Dr. Macculloch, it is the source of anything but good,—"a lottery which produces universal poverty among the people who pursue it." A recent account represents the case more favourably, and informs us, that there are a number of persons who live by this alone, and where there is a small family to gather the shells and pick out the fish, it is preferable to any other daily labour.‡ The pearls are disposed of to an overseer, who pays for them by the ounce, the price varying from 1*s.* 6*d.* to 4*s.* What is done with them seems to be involved in mystery: they are, with few exceptions, useless as ornaments, and the exceptions seem scarcely sufficient to support any profitable speculation; so that I give no credit

* Pennant, Brit. Zool., iv. 163.

† Phil. Trans. xvii. 660. In Sir W. Scott's description of the bridal attire of the Maid of Lorn, one of her attendants is thus introduced:—

> "While on the ankle's slender round
> Those strings of pearl fair Bertha wound,
> That, *bleach'd Lochryan's depths within*,
> Seem'd dusky still on Edith's skin."
>
> *Lord of the Isles*, canto i. 5.

‡ Mag. Nat. Hist. iii. 132.

to Mr. Murray's informer, who told him, "that a lady on the Conway nets nearly a thousand a-year by the pearls of that river, *under a charter*." * In Cumberland, the famous circumnavigator, Sir John Hawkins, had a patent for fishing the Irt, a river which Drayton dwells upon at more than his usual length:—

> " ——— Irt, of all the rest, though small, the richest girl,
> Her costly bosom strew'd with precious orient pearl,
> Bred in her shining shells, which to the deaw doth yawn,
> Which deaw they sucking in, conceive that lusty spawn,
> Of which when they grow great, and to their fulness swell,
> They cast, which those at hand there gathering, dearly sell!" †

In Scotland, Drummond sings of "the pearly Don;" and the recollection of the ancient celebrity of the Spey and the rivers of Perthshire has been kept alive by some modern attempts to revive the fishery, which at one time was so considerable that the historian has deemed it worthy his notice. "It is singular," says Mr. Tytler, "to find so pretious an article as pearls amongst the subjects of Scottish trade, yet the fact rests on good authority. The Scottish pearls in the possession of Alexander I. were celebrated in distant countries for their extreme size and beauty; and, as early as the twelfth century, there is evidence of a foreign demand for this species of luxury. As the commercial intercourse with the east increased, the rich oriental pearl, from its superior brilliancy, and more perfect form, excluded the Scottish pearls from the jewel-market; and by a statute of the Parisian goldsmiths, in the year 1355, we find it enacted that no worker in gold or silver shall set any Scottish pearls with oriental ones, except in large ornaments or jewels for churches." ‡ A vestige of this trade remained until a comparatively recent period; for we find that between the years 1761 and 1799, pearls to the amount of 10,000*l.* worth were sent from the Tay and Ila to London; and I believe there are still a few idlers on the banks of some of the large rivers of Scotland who procure a precarious livelihood by fishing the pearl-mussel. There were similar fisheries in the north of Ireland about a century and a half ago, carried on with considerable profit. Sir Robert Redding has given a good account of the mode in which the fishery was conducted; and notwithstanding the wearisome length of these details, you must permit me to give two short extracts from his paper, detailing the method of capture, and the kind of shell which indicated a margaritiferous fish. "The manner of

* Mag. Nat. Hist. iii. 451. † See also Fuller's Worthies, i. 337.
‡ Hist. of Scotland, ii. 306.

their fishing is not extraordinary. The poor people, in the warm months before harvest is ripe, whilst the rivers are low and clear, go into the water: some with their toes, some with wooden tongs, and some by putting a sharpened stick into the opening of the shell, take them up. And although by common estimate not above one shell in a hundred may have a pearl, and of those pearls not above one in a hundred be tolerably clear, yet a vast number of fair merchantable pearls, and too good for the apothecary, are offered to sale by these people every summer assize."—"The shells that have the best pearls are wrinkled, twisted, or bunched, and not smooth and equal as those that have none." "And the crafty fellows will guess so well by the shell, that though you watch them never so carefully, they will open such shells under the water, and put the pearls in their mouths, or otherwise conceal them. That same person told me, that when they have been taking up shells, I believed by such signs as I have mentioned, that they were sure of good purchase, and refused good sums for their shares, that yet they found no pearl at all in many of them. Upon discourse with an old man that had been longest at this trade, he advised me to seek not only when the waters were low, but in a dusky gloomy day also, lest, said he, the fish see you, for then he will shed his pearl in the sand: of which I believed no more than that some mussels had voided their pearls, and such are often found in the sands." *

After the discovery of America, the traffic in pearls passed, in a great measure, from the east to the shores of the western world. The first Spaniards who landed in terra firma found the savages decked with pearl necklaces and bracelets; and among the civilised people of Mexico and Peru they saw pearls of a beautiful form as eagerly sought after as in Europe. The hint was taken; the stations of the oysters were sought out; and cities rose into splendour and affluence in their vicinity, all supported by the profits on these sea-born gems. The first city which owed its rise to this cause was New Cadiz, in the little island of Cubagua; and the writers of that period discourse eloquently of the riches of the first planters, and the luxury they displayed; but now

* Phil. Trans. an. 1693, xvii. 660—662. It is a singular fact that Humboldt never heard of pearls being found in the fresh-water shells of South America, though several species of the genus Unio abound in the rivers of Peru.—*Pers. Nar.* ii. 282. They are to be found in those of North America. *Gould's Invert. Massach.* 115. In the Lach. Lapponica of Linnæus, ii. 104—107, the reader will find an account of a pearl-fishery in Lapland similar to our Scottish one.

not a vestige of the city remains, and downs of shifting sand cover the desolate island. The same fate soon overtook the other cities; for, from various causes, and particularly from the never ceasing and indiscriminate destruction of the Meleagrinæ, the banks became exhausted, and towards the end of the sixteenth century this traffic in pearls had dwindled into insignificance. Of its value, when first established, the following extract will give you some notion:—" The *quint*, which the king's officers drew from the produce of pearls, amounted to 15,000 ducats; which, according to the value of the metals in those times, and the extensiveness of the contraband trade, might be considered as a very considerable sum. It appears that till 1530 the value of the pearls sent to Europe amounted yearly, on an average, to more than 800,000 piastres. In order to judge of the importance of this branch of commerce to Seville, Toledo, Antwerp, and Genoa, we should recollect that at the same period the whole of the mines of America did not furnish two millions of piastres, and that the fleet of Ovando seemed to be of immense wealth, because it contained nearly 2,600 marks of silver. Pearls were so much the more sought after, as the luxury of Asia had been introduced into Europe by two ways diametrically opposite; that of Constantinople, where the Paleologi wore garments covered with strings of pearls; and that of Grenada, the residence of the Moorish kings, who displayed at their court all the luxury of the east. The pearls of the East Indies were preferred to those of the West; but the number of the latter which circulated in commerce was no less considerable in the times which immediately followed the discovery of America. In Italy, as well as in Spain, the islet of Cubagua, in the mouth of the Rio de la Hacha, became the object of numberless mercantile speculations."*

In the east the divers are hired labourers, bred up to their business, which, though a hard one, is voluntary, and appears to be less prejudicial to health than is sometimes asserted. It was far otherwise in the west, where, according to an historian, who has been accused of rather palliating than otherwise the cruelties of the Spanish adventurers, the Indians, unused to the practice, were compelled to dive for the oysters; and," he adds, " this dangerous and unhealthy employment was an additional calamity, which contributed not a little to the extinction of that devoted race."† It is when the memory of these forced labours and cruelties

* Humboldt's Pers. Narrative, ii. 279.

† Robertson's America, i. 190. 4to. See also Forbes in the Naturalist, iv. 313, &c.

come over us that our feelings rise against a trade which has seemingly no other object than

"To spangle the attires, and deck the amorous brows"

of our fair; and then we are disposed to sympathize in the sentiment which Mrs. Hemans has embodied in the following beautiful verses to the pearl-diver.

"Thou hast been where the rocks of coral grow,
Thou hast fought with eddying waves;
Thy cheek is pale and thy heart beats low,
Thou searcher of ocean's caves!

Thou hast look'd on the gleamy wealth of old,
Midst wrecks where the brave have striven;
The deep is a strong and a fearful hold,
But thou its bars hast riven.

A wild and weary life is thine,
A wasting toil and lone!
Though the treasure-grots for thee may shine,
To all besides unknown.

A weary life!—but a swift decay,
Soon, soon shall set thee free;
Thou art passing fast from the strife away—
Thou wrestler with the sea!

In thy dim eye, on thy hollow cheek,
Well are the death-signs read:
Go! for the pearl in its cavern seek,
Ere hope and power be fled!

And bright in beauty's coronal
That glistening gem shall be;
A star to all in the festive hall,—
But who shall think on *thee*?

None!—as it gleams from the queen-like head,
Not one midst throngs will say,
A life hath been like a rain-drop shed,
For that pale, quivering ray." *

The pearl-fishery of South America has of late years been revived, with what degree of success is unknown to me, though I believe it has been small. I have, indeed, seen it somewhere asserted that the value of the new trade is very considerable, and that Congress had, in 1823, granted the exclusive right of the Colombian fishery to Rundell, Bridge, and Rundell, of London, for the term of ten years. The "General Pearl and Coral Fishery Association" of London,

* "The Pearl-Wearer," a short poem by Mr. Proctor, has a similar tendency and moral. It is quoted by Dr. Baird in his tract entitled "Pearls and Pearl-Fisheries," which every reader interested in the subject should consult.—*Chambers's Misc. Usef. and Entert. Tracts*, No. 167.

in the year 1825, commissioned Lieutenant Hardy, an officer of great zeal and integrity, to establish a pearl-fishery in the gulf of California, but the speculation proved an entire and ruinous failure; not from any deficiency on the part of their clever agent, but from the deficiency of oysters, and their unproductiveness in the sought-for prize.* The pearl-oysters of this gulf, and of South America in general, are not found in beds or banks, but always in the cracks and crevices of rocks; and so "firmly does the oyster fix himself to the rock, that, in order to tear him away, it is necessary to get 'a purchase' upon him, by placing the feet on the bottom. The excessive difficulty of doing this is incredible; it requires the muscular strength of the whole body to overcome the resistance of the water's buoyancy."† And when at length a great number of shells were collected in the Gulf of Moléxa, alas! six very small pearls were all that the large number produced. The divers, too, seem to be exposed to greater danger than they are in the Indian Ocean from the attacks of sharks and other fish, to guard against which, they arm themselves with a stick about nine inches long, pointed at both ends. "The diver grasps it in the middle, and when attacked by a shark, he thrusts it into the monster's expanded jaws in such a position, that, in attempting to seize his victim, the jaws close upon the two sharp points; thus secured, he can do no mischief, but swims away with his martyrdom; the diver rises, and seeks a new weapon of defence." Lieutenant Hardy spiritedly describes the marvellous adventure of one of these divers, but the story is too long for me to transcribe in this place; and I hasten to finish this general survey of the pearl-fishery by noticing that which is now carried on to some extent in the Australasian seas. Captain Beechy tells us that there one vessel "sometimes collected seventeen hundred of these shells in one day;" and afterwards he mentions that the Queen of Otaheite, "seeing the estimation in which the

* "For one branch of commerce, the pearl-fishery, California has been famed from its first discovery. The glory and the riches derived from this source are, however, almost traditional: at least, the actual amount of the trade is insignificant. Nevertheless it is by no means certain that the sources of a beneficial commerce in this respect do not yet exist, provided proper means were taken for pursuing it with effect."—A. Forbes on the Pearl-Fishery of Lower California in the *Naturalist*, iv. 312, &c.

† Quart. Review, xlii. 344. Lieut. Hardy adds, "I have no doubt that, by means of its long beard, the oyster has the power of locomotion, and that it changes its situation according to its pleasure or convenience." Lieut. Hardy is entirely wrong here; the *beard* is a chain or cable which the animal cannot unfix.

pearl-oyster shells were held by Europeans, imagined that by levying a duty on them she would greatly increase her revenue;" and accordingly a duty was ordered to be levied, but the mode in which the order was put into execution led to unfortunate results, and the Queen was compelled to forego this plan of enriching her exchequer.*

Pearls are the toys of civilised nations, while shells themselves become the pride and ornament of savage tribes; for it is in poetry only that we find damsels who think themselves

——— "when unadorn'd,
Adorn'd the most."

A negro Venus with a large cowry (Cypræa) for an ear-pendant, another for a nose-jewel, and a string of volutes for a necklace, may, in the opinion of your fair lady, have a very ridiculous and childish taste, but, in reality, the one values her pretty shells as highly as the other doth her pearls. And this is no idle supposition: for I remember that Sir J. Banks could not, by any present, induce an Otaheitan girl to part with her native ornaments; and some tribes so curiously and neatly form their shells into festoons and bracelets, and wear them so gracefully, that even European travellers have expressed admiration of them.† Some years ago I saw, in the museum of Mr. Bullock, a very magnificent piece of dress of this kind. It was the chief mourner's dress of ceremony at the funerals of Otaheite. The part worn over the face was made of large plates of mother-of-pearl shell fastened together with fibres of the cocoa-nut; and the

* Voyage, i. 246, 281. The manufacture of artificial pearls is now a considerable branch of trade. Shaw says that the eyes of the cuttle-fish are strung, as pearls for necklaces, on the shores of Sicily and Naples.—*Duncan's Anal. of Organ. Beings*, 59. They appear to have been used as ornaments by the Peruvians also; and the natives of the Sandwich Islands have imposed them on the Russians as pearls.—*Gray, Spic. Zool.* 3. De Montfort says he has seen a necklace formed out of the nacred part of the Turbo smaragdus much more brilliant and beautiful than any of the finest orient pearls.—*Conch. Syst.* ii. 252.—Of the Turbines, Chenu tells us,—"Les grandes espèces fournissent une fort belle nacre, employée pour les ouvrages de marqueterie. Quelques espèces ont reçu des noms sous lesquels les marchands les distinguent: il y a le Burgau ou Nacré; la Veuve perlée, dont les tubercles extérieurs usés ressemblent à des perles; la Bouche-d'Or, dont la nacre est d'un beau jaune doré; la Bouche-d'Argent, le Perroquet ou Turbo impérial, &c., &c." *Leç. Elément.* 188.

† "The Fuegian necklaces shew some ingenuity in those who make them, being composed of small shells, perforated very neatly, and fastened together on strings of sinews or gut, so finely divided and platted, that one is, at first, inclined to doubt their being the manufacture of such uncouth savages."—*Voy. of Adventure and Beagle*, ii. 201.

elaborate drapery stretched across the breast was composed of several thousands of pieces of mother-of-pearl, each separately drilled and fastened together in a manner that would be found difficult for a European artist to copy, with the advantage of iron tools, which were then totally unknown to these interesting islanders.* The highest order of dignity, among the Friendly Islanders, is the permission to wear the orange cowry or Cypræa aurora.

To many people shells serve many purposes more useful than that of ornament. You must have read that in India, and among the various nations in Africa, a species of cowry (Cypræa moneta) is the current coin; and in the travels of Park you may see a table of their comparative value. The Iroquois, and other North American tribes, make their wampum, which serves the purpose of records, from the purple-edged valves of the Venus mercenaria; † and they have also a white wampum made with a species of the genus Cassis of Lamarck, or of various shells, which they string into a belt; and, according to Mackenzie, invariably present to strangers when they form or recognize a treaty of amity. The Japanese play a simple game, which they are very fond of, with the valves of a bivalve shell, apparently a species of Venus. "Divers curious figures are painted on the inside, and they serve as an amusement to the Court of the Dairi, or ecclesiastical hereditary emperor, who play with them after the following manner. Large heaps are thrown on the ground, and every one of the company having taken his portion, he wins that can shew the most pairs."‡ In Japan and the southern parts of China and India, the thin flat valves of Ostrea placenta are used instead of glass for windows. From several kinds, but more particularly from the mother-of-pearl shell, the natives of the Polynesian Islands fabricate their fishing-hooks with elaborate care and ingenuity, and they are considered much better than any made in Europe. Many of the domestic utensils of rude or savage people are shells; § and you must have observed that we have frequently imitated these in our porcelain. In India they form elegant drinking-cups of the Nautilus pompilius, which they render costly by carving and painting grotesque devices on its outer surface. Even in our own country, in the days

* A minute description of the dress is given by Mr. Ellis, Polynesian Researches, i. 412.

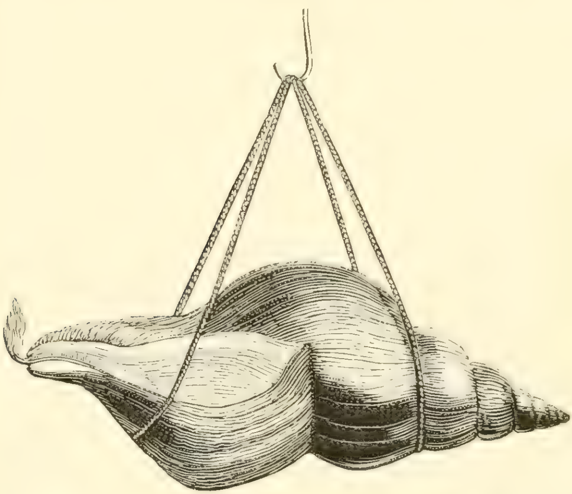
† Gould's Invert. Massachusetts, 86.

‡ Kæmpfer's Japan, i. 140.

§ A spoon is in Latin *cochleare*, because cockle-shells were first used for the purposes of a spoon. See *Fuller's Worthies*, i. 397.

when Ossian sang, the flat valves of the scallop (Pecten maximus or opercularis) were the plates, and the hollow ones the drinking-cups, of Fingal and his heroes; hence the term *shell* became expressive of the greatest hospitality.* "Thou, too, hast often accompanied my voice in Branno's hall of shells." "The joy of the shell went round, and the aged hero gave the fair;" and there are many passages of a similar import in the poems of the Celtic bard; nor, perhaps, is the custom to which they allude yet wholly extinct. "We were entertained in the island of Col," says Boswell, in his tour to the Hebrides with Johnson, "with a primitive heartiness. Whiskey was carried round in a shell, according to the ancient Highland custom. Dr. Johnson would not partake of it; but, being desirous to do honour to the modes 'of other times,' drank some water out of the shell." It is now applied to less honourable and more useful purposes. The

Fig. 9.



modern maiden of the Western Isles skims her milk with it, or forms it into a spoon for lifting butter, and none can be more elegant and better suited to the purpose. In Zetland the Fusus antiquus (Fig. 9), suspended horizontally by a cord, is used as a lamp, the canal serving to hold the wick, and the cavity to contain the oil. Examine the sketch, and then tell me if it is not probable that some of the most ele-

* "Shells were the only drinking-vessels of the Britons, and are even used by the Highlanders at present."—*Whitaker's Manchester,* ii. 19.

gant patterns left us by the Greeks have been suggested by a similar primitive practice? But, indeed, at all stages of society artists have sought for models in the study of shells, which afford some of the most agreeable forms in nature. I do not here allude to the Nautilus, whence, as some ingenious men have conjectured, man took his first notions of ship-building and sailing; nor to the Solarium perspectivum, whose umbilicus, characterised by Linnæus as a "stupendum naturæ artificium," the same fancy makes out to be the type of the hanging staircase; nor even to the Buccinum (Tritonium variegatum, Lamk.), which is more clearly the original of the war-trumpet,—

> ——— "The shell proclaims
> Triumphs, and masques, and high heroic games;"*

but ornamental workers in general have often professedly made them the subjects of close imitation, as I have already said is the case in our porcelain manufactory; and many personal ornaments—our brooches, seals, and boxes—are mere copies of shells. When these were first collected into museums, it was no love of science, nor ambition to promote it, that prompted the collectors; it was the pleasure which the contemplation of their varied colours, their elegance and singularities of form gave to the eye and mind, and hence they were then not arranged, as now-a-days, singly and in labelled cabinets, but mixed, contrasted and combined in every possible way and in many fantastic figures, while every

* Captain Cook observes that he never knew the blowing of the conch in Australasian tribes to portend good; it seemed to be the signal for a hostile attack. Mr. Ellis says, "These shells were blown when a procession walked to the temple, or their warriors marched to battle, at the inauguration of the king, during the worship at the temple, or when a tabu, or restriction, was imposed in the name of the gods. We have sometimes heard them blown. The sound is extremely loud, but the most monotonous and dismal that it is possible to imagine."—*Polynesian Researches*, i. 197. I need scarcely recall its use among the early Romans—

> "Buccina jam priscos cogebat ad arma Quirites."

Pietro Martire thus describes a custom of the native Americans:—"The doors of their houses and chambers were full of diverse kindes of shells, hanging loose by small cordes, that being shaken by the wind they make a certaine rattelling, and also a whistling noise, by gathering the wind in their holowe places; for herein they have great delight, and impute this for a goodly ornament."—Southey's *Madoc*, ii. 224. Hence Southey, in his description of the Festival of the Dead:—

> ——— "Not a sound is heard,
> But of the crackling brand, or mouldering fire,
> Or when, *amid yon pendent string of shells*,
> The slow wind makes a shrill and feeble sound,—
> A sound of sorrow to the mind attuned
> By sights of woe."

art was used to heighten their native hues, and, it may be, to rub down whatever were deemed deformities. This taste spread from the museum; and figures of the same kind, but of large size, were introduced into the garden, where Tritons, Mermaids, and Neptunes arose, wholly fabricated of shells, spouting water all very fine and blowing conchs most mightily.* Bonanni in his book entitled "Recreatio Mentis et Oculi," has given a few figures illustrative of this rude taste as they were to be seen in the royal gardens at Versailles, and which he lauds as the perfection of art and beauty. When carvings in wood came into fashion, shells were again favourite objects of imitation; and, at a later period, they were admirably copied by workers in plaster, so that I have repeatedly, in some of our old chimney-pieces, studied with pleasure the groups of shells represented there; and so well, that it has not been difficult in many cases to identify the species. This pretty work is now rarely seen, which I do regret, although the expression of it exposes me to the charge of a certain vulgarity in taste. But no artist ever applied a shell to so noble a purpose (and the fact is a fine example, that genius rests its high efforts on no uncommon or new facts peculiar to its own sphere of observation, but on every day and familiar processes, which she views with her own heavenly light,) as Mr. Brunel did when the borings of a Teredo revealed to him the plan of tunneling the Thames! On a visit to this distinguished engineer by Professor Pictet and Dr. Brewster, he mentioned to them that the idea upon which his new plan of tunneling is founded, was suggested to him by the operations of the Teredo.† Is this not sufficient compensation for all the ravages of that worm?

A few shells have been applied to religious purposes. The Achatina perdix, (Lamk.) is said to be so highly valued in the East Indies that its exportation has been prohibited under pain of death, possibly owing to some superstitious

* "Cœruleum Tritona vocat; conchaque sonanti
Inspirare jubet, fluctusque, et flumina signo
Jam revocare dato."—Ovid.

† Edin. Encyclop. xviii. 656. After alluding to the numbers and variety of the species of the genus Cerithium, Lamarck adds, "Or, comme l'extrême diversité des parties protubérantes de la surface de ces coquilles, ainsi que la régularité et l'élégance de leur distribution, ne laisse presque aucune forme possible dont la nature n'offre ici des exemples, on peut dire que l'architecture trouverait dans les espèces de ce genre, de même que dans celles des pleurotomes et des fuseaux, un choix de modèles pour l'ornement des colonnes, et que ces modèles seraient très-digne d'être employés."—*Anim. s. Vert.* vii. 64.

reverence attached to it.* Reversed varieties of the Turbinellus pyrum, or Chank, are held sacred in China, where great prices are given for them; and they are kept in pagodas by the priests, who, on certain occasions, administer medicines to the sick from them, and also use them to anoint the emperor at his coronation.† Blumenbach informs us that the same shell is made into arm and finger rings, and worn by the poorer Hindoos. After their death, these rings are thrown by their relations into some holy river, and never again taken up by any of the people; hence, he adds, the great consumption of such rings, and the importance of the fishery for the shells from which they are manufactured.‡ The negroes of Prince's Island lay a string of the Helix bicarinata above the door of their cabins as an agreeable fetiche to their god, fitted to draw down his protection over their modest hearths; but the shell being one on which conchologists set a high value, and in consequence an object of commerce, the devotion of the negroes has yielded to avarice, and the fetiche is now exchanged for tobacco, spirits, old clothes, and toys.§ In the dark ages a scallop (Pecten jacobæus), fixed to the hat in front, was the emblem of the pilgrim journeying to the Holy City;‖ and to this custom allusion is occasionally made by our poets and popular writers. Thus the love-crazed Ophelia in her song:—

"How should I your true love know
From another one?
By his *cockle-hat* and staff,
And his sandal shoon."

And thus Parnell says of his hermit:—

"To clear this doubt, to know the world by sight,
To find if books or swains report it right,
He quits his cell, the pilgrim staff he bore,
And fixed the *scallop in his hat before*."

* Clarke's Travels, Scandinavia, i. 75.

† Dillwyn's Desc. Catalogue, 569.

‡ Elem. of Nat. Hist. 260. The principal "Chank Fishery" appears to be that of Ceylon, and is of sufficient importance to be regularly farmed and carried on under a set of regulations prescribed by government. It produces an annual rent of about 41,100 rix dollars.—*Asiatic Journal* for April, 1827, p. 469, &c.

§ Ann. des Sc. Nat. xxiv. 27. For other religious applications of shells the reader may consult Bonanni, Rec. Ment. et Ocul. 77 *et seq.*; and Conchologist's Companion, 52.

‖ "It is not easy to account for the origin of the shell as a badge worn by pilgrims; but it decidedly refers to much earlier Oriental customs than the journeys of Christians to the Holy Land, and its history will probably be found in the mythology of Eastern nations."—Clarke's *Travels*, ii. 538, 4to.

and thus Wordsworth, when he celebrates the hospitality of the "hooded Celibates" of St. Bees:—

> " ——— nor do they grudge the boon
> Which staff and *cockle-hat* and sandal shoon
> Claim for the pilgrim."*

Fig. 10.

You will now admit that the Mollusca have contributed their due share to ornament "the outward man;" and you could scarcely expect such animals to do more in the way of clothing us. Nor do I mean to surprise you by finding amongst them a rival to the silk-worm, for indeed the claims of the silk-spinning Mollusca are very trifling. But the Pinnæ (Fig. 10), a curious genus of the bivalved class, do spin a kind of silk, which has been woven into some articles of dress, in early times so highly prized as to have been set aside for the use solely of emperors and kings. This silk is the byssus, or rather the cable, of the animal, by means of which it is moored to the rocks, in the same manner that our common mussel is. In a crude state the silk is called *lana penna:* the threads are extremely fine, of a perfect equalness in diameter through their whole length, and of great strength. It is cleansed from its impurities by washing in soap and water, drying and rub-

* "The abbey of St. James, in Reading, gave *Azure, three scallop-shells or.* Here I know not what secret sympathy there is between St. James and shells; but sure I am, that all pilgrims that visit St. James of Compostella in Spain (the paramount shrine of that saint), returned thence obsiti conchis, 'all beshelled about' on their clothes, as a religious donative there bestowed upon them." Fuller, *Ch. Hist.* ii. 228. On shells in heraldry, see a beautifully-illustrated and interesting volume, entitled 'The Heraldry of Fish,' p. 220—228, by Thomas Moule: Lond. 1842. Also, Gibbon's Life, p. 15.

bing with the hands. "It is then passed through combs of bone, and afterwards, for finer purposes, through iron combs, or cards, so that a pound of the coarse filaments is usually reduced to about three ounces of fine thread. When mixed with about one-third of real silk, it is spun on the distaff, and knit into gloves, caps, stockings, vests, &c., forming a stuff of a beautiful brownish-yellow colour (resembling the burnished golden hue on the back of certain flies and beetles), but very liable to be moth-eaten, and requiring to be wrapped in fine linen. A pair of gloves costs on the spot about six shillings, and a pair of stockings eleven; but its sale is not very extensive, and the manufacture is peculiar to Taranto."* You can see a pair of gloves made of this material in the British Museum.

The most costly and brilliant dye of which we read in history was procured from shell-fish. This is the Tyrian purple —"that glorious colour, so full of state and majestie, that the Roman lictors with their rods, halbards, and axes, make way for: this is it that graceth and setteth out the children of princes and noblemen: this maketh the distinction between a knight and a counsellor of state: this is called for and put on when they offer sacrifice to pacifie the gods: this giveth a lustre to all sorts of garments: to conclude, our great generals of the field, and victorious captaines, in their triumphs weave this purple in their mantles, enterlaced and embroidered with gold among. No marvel therefore if purples be so much sought for: and men are to be held excused, if they run a madding after Purples."† The dye was discovered by the Phœnicians; and Aristotle and Pliny give nearly the same account of the process by which it was procured. They tell us that the liquor was contained in a transparent branching vessel or vein placed behind the neck of the animal, and that it was at first of the colour and consistence of thick cream. When the shells were small, the whole were bruised together in a mortar; but when large, the fish were first removed, the receptacle of the dyeing liquor taken out, and this mixed with a considerable quantity of salt to keep it from putrefying: "It was then diluted with five or six times as much water, and kept moderately hot in leaden or tin vessels, for eight or ten days, during which the liquor was often skimmed to separate all the impurities. After this, the wool to be dyed, being first well washed, was immersed and kept therein for five hours; then taken out, cooled, and again immersed, and continued in the liquor till all the colour was

* Edin. Encyclop. xii. 372. † Holland's Plinie, i. 258.

exhausted.*" It is very plain, from their account, corroborated as it is by many other testimonies, that univalve shell-fish did furnish this dye; and there can be no hesitation in rejecting as entirely groundless the opinion of Mr. Bruce, the Abyssinian traveller, that the purple-fish at Tyre was only a concealment of the Tyrian's knowledge of cochineal.†

The exact species of shell-fish which furnished the true dye has, however, been made a subject of particular inquiry and of some dispute; for here, as in relation to many other objects of natural history, the descriptions of the ancients are so vague, that the attainment of certainty is often impossible. It may be safely inferred from Pliny's account, that there were several species, all of them referable to the genera Murex and Buccinum of Linnæus, and native, one of them to the shores at Tyre; another or the same to Africa within the island Meninx or Zerbi, and by Getulia; another to Laconica in Europe,—these affording a dye of different intensities of colour, presumed to depend on certain specialities in the food or in the nature of the soil.‡ Fabius Columna, a Neapolitan nobleman, and the best authority on this question, believes that the Purpura of Pliny is the Murex trunculus of Linnæus (Fig. 11), one of the commonest shells of the Mediterranean;§ while the Buccinum of the Roman naturalist may be the Purpura patula (Lamk.), though the correspondency of external characters is, in the latter instance, less exact. The Purpura lapillus so abundant on our own, and on the shores of Europe in general, is very likely to have been the principal of the lesser sort of Purples; but it is impossible for us to give assent to the conjectures of M. Lesson,|| that the ancient purpuriferous Buccinum was the Ianthina fragilis, because the coloured liquid excreted by this singular mollusk is purple on its emission, is contained within a gland of a different character from a vein, and is remarkably defective in permanency, the very quality

* Thomson's Hist. of Chemistry, i. 91. † Travels, i. 63, Introd.

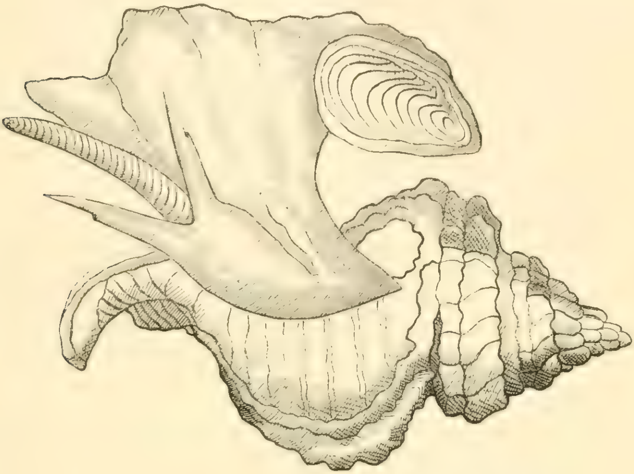
‡ Purple dye was obtained from the Murex, Purpura, and Conchylium. Pliny mentions also the Buccinum and Pelagium. The Buccinum alone was not approved of; but when united with the Pelagium, gave a deep bright colour. The dye of the Conchylium appears to have been less deep than that of the Purpura. Pliny distinguishes three shades of colour—tyrium or purpura, amethystinum, and conchylium. The first was like congealed blood or deep crimson; the second like the amethyst or violet; the third a lighter pink or blue, as in the plants heliotropium, malva, and viola serotina. He also says that the conchylium had a strong unpleasant smell, and resembled in colour the sea in a storm.

§ Dr. Wilde has proved that this was one of the shells, and probably the principal one. Ann. Nat. Hist. iii. 271.

|| Loudon's Mag. Nat. Hist. i. 389.

which imparted its chief value to the real dye. The same reasons prevent us concurring in the guesses of those who enumerate the Aplysia depilans and Scalaria clathrus among the Purples.*

Fig. 11.



From the simplicity of the art of dyeing with the Tyrian purple,—the simple application of the fluid to the dress and exposure to light, without any further process, and without the use of any mordant, being all that is necessary,—its early discovery was to be expected. Accordingly we are told that it was the first colour which mankind were enabled to fix permanently on wool and linen; and its invention is lost in fable. While a certain Hercules strolled along the shore with his lady-love and her dog, the latter, in its sport, mouthed a shell which had been tossed up by the waves, and had his lips coloured with the purple juice. The lady, surprised with the beauty of the colour, yearned for a dress of the same purple, and the wish sufficed to call into exercise the ingenuity of her lover, who was enabled to gratify her wishes! This discovery is presumed to have been made 1400, or, at the utmost, 1500 years before the Christian era; and it was perhaps the principal commodity of Tyre when its "merchants were princes, and its traffickers the honourable of the earth." You well know how greatly its beauty and permanency have been lauded by poets as well as naturalists; but

* Edin. New Phil. Journ. v. 403.

from its scarcity the dye was always very costly, and in consequence reserved for dyeing the hangings of temples, or the robes of priests and kings. The hue of the best resembled that of coagulated blood,* but means were resorted to by which various tints were obtained, and the cloth was often stained first of one shade, and then dipped into a deeper coloured liquid to give it a fuller and richer gloss. "Wool which had received this double Tyrian dye (*dia bapha*), was so very costly that, in the reign of Augustus, it sold for about 36*l.* the pound. But lest this should not be sufficient to exclude all from the use of it but those invested with the very highest dignities of the State, laws were made inflicting severe penalties, and even death, upon all who should presume to wear it under the dignity of an emperor. The art of dyeing this colour came at length to be practised by a few individuals only, appointed by the emperors, and having been interrupted about the beginning of the twelfth century all knowledge of it died away, and during several ages this celebrated dye was considered and lamented as an irrecoverable loss."

But though the art was lost to the places which gave it birth, and which it had enriched, in our own island it was practised at the very time when the learned lamented it as extinct, and where it seems to have been known from time immemorial, being probably rather an art of native growth than the importation of a foreign commerce; and, perhaps, it were no errant conjecture to suppose that it might be the colour

> "By which our naked ancestors obscured
> Their hardy limbs, inwrought with mystic forms,
> Like Egypt's obelisks."

The Venerable Bede, who wrote in the eighth century, mentions the art as a known thing in his days, and he was familiar with the beauty and permanency of the colour.† The

* "In the Greek language, *purple* and porphyry are the same word; and as the colours of nature are invariable, we may learn that a dark deep red was the Tyrian dye which stained the purple of the ancients."—GIBBON, *Dec. and Fall*, ix. 57.

† The passage is quoted by Dr. Lister in a paper on the subject in the Phil. Trans. for 1693, p. 645, and is as follows:—"Variis conchyliorum generibus exceptis: in quibus sunt et musculæ, quibus inclusam sæpe margaritam omnis quidem coloris optimam inveniunt; id est, et rubicundi et purpurei, et hyacinthi et prasini, sed maxime candidi. Sunt et cochleæ satis superque abundantes, quibus tinctura coccinei coloris conficitur. Cujus rubor pulcherrimus nullo unquam solis ardore, nulla valet pluviarum injuria pallescere; sed quo vetustior, eo solet esse venustior."—*Hist. Eccles. Gent. Ang.* lib. i. c. 1.

same fact is mentioned by Richard of Cirencester,* and also in a translation of Higden's Polichronicon made in the year 1387.† The language used by these authors implies that the art was familiarly known and followed, but, from its limited utility, it seems gradually to have gone into disuse, until at length a few families only preserved the custom of the olden time, and handed it down to their posterity as a family secret. In 1684, Mr. William Cole, of Bristol, having been informed that "there was a certain person living by the sea-side in some port or creek in Ireland, who made considerable gain by marking with a delicate durable crimson colour fine linen of ladies, gent., &c.,"—a colour which was "taken out of a shell-fish,"—was induced to institute some experiments on the common shell-fish of our coast, and after various trials he succeeded in finding the object of his search in the Purpura lapillus. After breaking the shell carefully, "there will appear," he says, "a white vein lying transversely in a little furrow or cleft, next to the head of the fish,"—a description you will remark in exact accordance with Aristotle's,—and in this vein the white viscid liquor is found with which the linen is to be marked.‡ Jussieu made similar experiments, in 1709, on the shores of France; which, in the year following, were repeated by the celebrated Reaumur, who has given a very interesting account of his inquiry in the Histoire de l'Académie des Sciences Naturelles for 1711. Reaumur also accidentally discovered that the egg-vesicles of the Purpura afforded the dye in greater abundance, and with less trouble to the experimenter, than the fish itself. These vesicles, which are of a vase-like shape, and about the size of grains of wheat, hang in clusters under shelving rocks; and although Reaumur could never satisfy himself whether they were the eggs of the Purpura, or the eggs of some fish on which it fed, their nature is no longer uncertain. The experiments of these naturalists have been subsequently repeated by others, so that the nature of the dye is now well-known. It has been ascertained, too, that

* Desc. of Britain, 28.

† "Ther beth ofte take delphyns and see calves and balenys gret fishes as hit were a whalles kynde and dyverse maner shelle fishe. among the shelle fishe beth muscles that hath among hem mariory perles of all maners coloure and hew rody and reed of purple and of blew and specialy most of white. ther is also of shel that we dieth with fyne reede. the rednesse ther of is wondre fayre and stable and steyneth never with colde ne with hete ne with drie but ever the eldere the hew is fayrere."—Book i. ch. 38 of "Bretayn." For this extract I am indebted to the Rev. Jos. Stevenson, so well known for the extent of his acquaintance with our early historical literature.

‡ Phil. Trans. xv. 1280.

the Chinese make use of a similar dye; and in the new world, according to Don Antonio de Ulloa, the inhabitants of the provinces Guayaquil and Guatimala have, time out of memory, procured it from certain conchs or sea-snails about the size of small nuts, or a little larger. The colour is in great estimation among them from its scarcity; "and, indeed, there is hardly any thing dyed with it but laces, borders, fringes, and such like works."*

The scarcity of the colouring liquid, and the discovery of cochineal, have rendered the Tyrian purple valueless as an object of commerce. Dr. Bancroft thinks it might still be rendered beneficial in staining or printing fine muslins, for which little colouring matter is required; and Mr. Montagu strongly recommends it for the purpose of marking linen, since the colour grows brighter by washing, and cannot, so far as is known, be removed by any chemical agent. It in fact excels all animal colours in durability and unchangeableness, as well as in the simplicity of its application. "It is strictly and preeminently," says Dr. Bancroft, "entitled to the distinction of a *substantive* colour, as it may be permanently fixed, even upon linen and cotton, by the most simple application, and without any preparation or admixture whatever; and it is admirable for the singular constancy with which it proceeds through the series of intermediate colours (according to their prismatic arrangement), until it has permanently fixed itself, and attained that purple tint which the Author of nature, for some unknown purpose, has fitted it to display; and all this in spite, if I may so express myself, of many powerful chemical agents, whose utmost influence extends only to retard, for a few hours, the ultimate accomplishment of this its destiny."† The changes alluded to in this passage are these: the fluid, when in the living animal and on its first extraction, is cream-coloured, or, as Reaumur has happily said, it has the appearance and consistence of well-formed pus. When applied to the cloth, it appears at first of a pleasant light green colour, and being exposed to the light the green gradually increases in intensity, from a deep green to a full sea-green; then it passes to a watchet blue, which soon acquires a tint of red, and at

* Gent. Mag. xxiii. 461.—"There is one further particular relating to this shell-fish which is very remarkable, and that is, that its weight and the colour of its juices are different at different hours of the day; and that there is a certain hour when the weight of the fish is the greatest, and the colour in the highest perfection; and this is so well known to the dealers in this commodity at Nicoya, that the hour when the fish is to be weighed and delivered is always particularly mentioned in the bargains and contracts."

† On Permanent Colours, i. 158.

last waxes to a very deep purple-red. The light and air can do no more; but if the cloth is now washed in scalding water and soap, it comes out from the lather of a fair bright crimson, which no subsequent process can change or lessen. While the cloth, wet with the dye, lies in the sun it exhales a strong fœtid smell, as if garlic and assafœtida were mixed together,* nor am I aware how this was got rid of in ancient practice, for I presume it is a quality inherent in the secretion of all purpuriferous fish, notwithstanding that Pliny's mode of expression would seem to imply that the "stinking savour" was peculiar to the less esteemed kinds. When exposed to the light, the colour runs through all the above changes in a few minutes; and if the light or heat be very strong, they succeed one another so quickly that the intermediate hues cannot be observed. By moderating the light the process is prolonged, and the whole series may be noted with accuracy; and if the light is excluded entirely, no change whatever takes place, but the dye remains of its native pale yellow or cream colour, and will so remain for years, until the admission of light revives its dormant energies. Dr. Bancroft kept pieces of linen stained with the liquor for nine years between the leaves of a book without any visible change, but which, at the expiration of that period, were influenced by light in the same way as recently-stained pieces, and as readily acquired the glowing purple. There are two ways of explaining this curious series of changes. We may suppose, with Berthollet, that they are owing to the base gaining additional doses of oxygen from the atmosphere and varying its hue accordingly; but, though this explanation has been received by many good chemists, Dr. Bancroft appears to have satisfactorily proved that the very opposite is the true theory;—the base parting with a redundant portion of oxygen "naturally combined for some unknown purpose in the liquor of these shell-fish; and in that particular state which will not admit of its being separated without the application and assistance of light; as is also the case of horned silver, rendered purple by the sun's rays; of vegetables, rendered green by the same cause, after they had become white by growing in darkness; of peaches, purple grapes, and other fruit, which never acquire their proper colours by any degrees of heat, but always remain white or green, if shaded and secluded from the contact of the sun's rays."†

* Cole in Phil. Trans. xv. 1280-1.

† On Perm. Colours, i. 145.—This work contains the fullest and best account of the Tyrian purples of any I have had the opportunity of reading.

Another article highly valued in the arts, the China or Indian-ink, is very generally believed to be manufactured fron the black liquor excreted by certain cephalopod mollusca, more especially, according to Bosc, from the Sepia rugosa: but the fact, however confidently some have affirmed it, cannot be said to be determined in the affirmative at least.* The colour called sepia is, however, composed almost solely of the cuttle's secretion; and, from various passages in the Latin writers, we learn that the same was used in their days in lieu of writing-ink. In Italy an ink is still prepared from the liquor in question, which Cuvier says differs from the genuine China-ink only in being a little less black. The liquor—and that of the Octopus and Loligo, is preferable to that of the Sepiæ—is expressed from the cellular tissue of its bladder in the state of a thickish bouillie, which diffuses itself readily in water and blackens a very considerable quantity. Received into a vessel, it dries in a few hours, and detaches itself in scales, similar to those of China-ink. With this preparation Cuvier drew the beautiful designs which illustrate his memoir; and he thinks it would be easy to originate a little branch of industry on whatever coasts these cephalopods abound.† I suspect not; for, according to the experiments of Dr. Bancroft, the ink of the cuttles, although durable enough, is otherwise objectionable; the strokes of the pen are not uniformly black, from the carbonaceous particles not being equally dispersed through the fluid, which, moreover, is liable to putrefy, and in its natural state could not be long preserved for the purposes of ink, unless the carbonaceous matter were separated from the animal mucilage, and mixed with a solution of gum arabic.‡

The mother-of-pearl, applied in so many ways, as you are well aware, to ornamental works, is got from the pearl-oyster and from the large bivalve shells allied to it, and native of the same seas. Cameos are cut on some thick shells with a nacred inner layer. With the powdered bone or shell of the Sepia, silversmiths make excellent moulds for casting articles of small work, such as spoons, forks, and rings; and statuaries and china-menders mix the glairy fluid of the garden-snail

Besides those already referred to, the curious reader may consult Aristotle, Hist. Animal., lib. v. cap. 13; Edinb. Encyclop. viii. Art. Dyeing; Thomson's Hist. Roy. Soc. 67, &c.; Beckman's Hist. of Inventions, vols. i. and ii.; Pennant's Brit. Zool. iv.; Montagu's Test. Brit. Supp. 105, 108, 120, &c. Aldrovandus has gathered together everything ever said on the subject previous to his own time, but his chapters are tedious beyond endurance.

* Griffith's Cuvier, part xxxix. 289.

† Mem. sur les Mollusq. i. 4, 5.

‡ On Colours, ii. 431.

with white of eggs and quick-lime to make a cement strong enough for their purposes. "Fractured marble and china are put together with the greatest expedition and firmness with this composition. The statuary, the pictorist, and medalist, also apply the sanies of this reptile to their moulds, before they take off their impressions with wax, making the waxen figures come off with more ease, and with a finer skin."*

Amongst the Mollusca there is not one which gives any essential aid to the physician, in his work of ministering to our ailments. In the Natural History of Pliny, indeed, there is a catalogue of medicines furnished by these animals sufficiently extensive and varied, but their reputation has passed away; for if oyster-shells and the bone of the cuttle-fish (Sepia officinalis) still hold a precarious place in some pharmacopœias, it is more from respect to ancient usage than from a conviction of their utility. Pearls long maintained a great medicinal reputation, descending from the testimony of the Arabian physicians; and who in the least acquainted with medicine has not heard of the virtues of the Unguis odoratus and Blatta Byzantina over vapours and epilepsy? The latter was the operculum of a species of Strombus, or, according to some, of a Turbo, and seems to have succeeded the Unguis odoratus in practice, when this ceased to be brought into Europe. The Unguis itself was a fresh-water bivalve shell, "gathered in the nardiferous lakes upon the river Ganges," and something like our own fluviatile bivalves (Cyclas). "I lament its loss," says the learned Dr. Lister, "which I have reason to believe was a good medicine, from its strong aromatic smell, which is much wanting in our testaceous powders, of which this was one of the number, so much used, and that not without good reason now-a-days, which are all very flat and insipid."†

Discarded from the service of the physician, a few Mollusca have found a resting-place in the Materia Medica of the common people, who inherit to the full their wise ancestors' faith in their virtues, which are enhanced by some superstitious traditions and observances. Slugs and snails were anciently, and are to this day, a popular remedy in consumptive complaints.‡ They are sometimes made into a mucilaginous broth, sometimes swallowed in a raw state, and

* Wallis, Hist. Northumb. i. 368; Barbut. Gen. Verm. 74.

† Phil. Trans, xvii. 643-644. Adanson, Senegal, Coq. 141.

‡ "Aqua ex limacibus distillata hepar imbecillum mirè roborat, et phthisicis remedium est, et hecticis."—SIB. *Scot. Ill.* ii. lib. 3, p. 34.

sometimes the shell is pricked through with a large pin to enable the patient to suck the oozing liquor. You may see considerable quantities of Helix pomatia and aspersa sold in Covent-garden market for this purpose; and still greater quantities are sold in all the large continental cities. In the Isle of Bourbon, the Navicella elliptica is commonly used to make a soup for the sick; and in the same and adjacent islands the animal of Melania amurula, which is very bitter, passes for an excellent remedy in the dropsy. The "piedra de las ojos," which are merely worn fragments of shells, are considered in some parts of South America as the most extraordinary production of their coasts, being, in the philosophy of the natives, both a stone and an animal. These fragments are from one to four lines in diameter, with a plain and a convex surface, and when excited by lemon juice move in proportion as the carbonic acid is disengaged. Placed in the eye, the pretended animal turns on itself, and expels every other foreign substance that may have been accidentally introduced. At the salt-works of Araya, and at the village of Maniquares, they were offered to Humboldt and his fellow-traveller by hundreds, and the natives were not only earnest to shew them the experiment of the lemon-juice, but wished to put sand into their eyes that they might themselves try the efficacy of the remedy.* The same custom and superstition is said to prevail in Guernsey; and in the olden time did prevail in the Highlands of Scotland. The Rev. John Frazer, writing of the year 1702, says: "Snail-stones are much commended for the eyes; and I'm confident their cooling vertue is prevalent against pains bred by a hott cause: ther origine is thus, some excrementitious parts avoided by these creatures, condensed by the circumjacent air, and turned to a round figure by the frequent turning; but this is observable, that some of them, speciallye snaile-stones, has the exact figure of the snail." †—But what are all these to the use which the pretty maidens of merry England and of Ireland‡ apply the snail in a May morning, when, in the

* Pers. Narrative, ii. 288—290. New Eng. Journ. of Med. and Surgery, v. 192.

† Analecta Scotica, i. 119. But the "Snail-stone" of Scotland, to which many mysterious virtues were long ascribed, was an artificial ornament made of blue glass. See Llwyd in Phil. Trans. abridg. vi. 21. Mr. Frazer's snail-stones are clearly different.

‡ "The *Drutheen,* which is supposed to possess the power of revealing the name of a sweetheart, is a small white slug, or naked snail; and it is the common practice of boys and maids, on May morning, to place one on a piece of slate, lightly sprinkled with flour or fine dust, covering it over with a large leaf, when it never fails to describe the initial of the one-loved name." —Croker's *Irish Fairy Legends,* ii. 215.

meanders of the slime-tracked creature they decypher—may neither eye nor fate deceive them!—the initial of the one-loved name!

> "Last May-day fair I search'd to find a snail,
> That might my secret lover's name reveal.
> Upon a gooseberry bush a snail I found,
> For always snails near sweetest fruit abound.
> I seized the vermin, home I quickly sped,
> And on the hearth the milk-white embers spread.
> Slow crawl'd the snail; and, if I right can spell,
> In the soft ashes mark'd a curious L.
> Oh! may this wondrous omen lucky prove!
> For L is found in Lubberkin and Love." GAY.

And, in my younger days, I remember the country school-boy, while strolling, with satchel on his back, from his hamlet to the neighbouring village, would stay to solicit, by doggerel rhymes, the black slug (Arion ater) to protrude its horns; and, having seized them according to the prescribed rules, would go on his way with a gayer heart and elevated hopes. Ay, and I have envied the better fortune of my fellow, who could tell, by the sounding of his whelk, of storms at sea, and of the fluxes of the tide! For, with Wordsworth, I have oftimes seen

> "A curious child, who dwelt upon a tract
> Of inland ground, applying to his ear
> The convolutions of a smooth-lipp'd shell;
> To which, in silence hush'd, his very soul
> Listen'd intensely, and his countenance soon
> Brighten'd with joy; for murmurings from within
> Were heard,—sonorous cadences whereby,
> To his belief, the monitor express'd
> Mysterious union with its native sea."

How beautifully has Landor described the same phenomenon and custom, when of the sinuous shells he sings

> ———————— "Of pearly hue
> Within, and they that lustre have imbibed
> In the sun's palace porch—where, when unyoked,
> His chariot wheel stands midway in the wave.—
> Shake one, and it awakens—then apply
> Its polished lips to your attentive ear,
> And it remembers its august abodes,
> And murmurs as the ocean murmurs there."

Nay! say not that I trifle, but rather condescend to my humour; for truly these are notices in which I more consult my own eccentricity of taste than the approval of your sober criticism; but in all my studies in natural history, I have

ever gladly associated them with reminiscences of the customs of the village now fled away, and with the descriptions and moralities of our native poets; and nothing loth am I to follow, when they throw me back upon a period of early life and its amusements, to which I ever recur with fond delight. And, moreover, I plead the authority of some early fathers in natural history, who, in their good old-fashioned way, never failed to append a chapter or verse, headed, "The Moral," to all their themes; and, under the protection of their names, I will even venture to give you one more quotation, fraught with wisdom, and which, if duly pondered, shall more than compensate for all my previous puerilities. What says the learned Dr. Donne:—

> "Be then thine own home, and in thyself dwell;
> In anywhere;
> And seeing the Snail, which everywhere doth roam,
> Carrying his own home still, still is at home,
> Follow (for he is easy paced) this snail;
> Be thine own palace, or the World's thy jail."*

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* Athenæus mentions that Hesiod calls the snail φερεοικος, "house-carrier;" and he quotes from Anaxilas:—

> "You are much more suspicious than the snails,
> Which through distrust always carry their house along with them."

I need scarcely remind the reader of Vincent Bourne's Ode, "Ad Limacem," nor of its translation by Cowper.

LETTER V.

THE SHELL CONSIDERED IN ITS RELATION TO OTHER ANIMALS.

The mollusk or snail is dead,—and you naturally conclude that the shell, having served the purposes of its legitimate proprietor, has now become a useless thing in its relations to the animal kingdom, left, like other organized fabrics, to decay and moulder into dust under the operation of the elements to which it is exposed. It was formed for a single specific use,—to cover and protect its native architect,—and being admirably adapted to that use under many variations of structure, the design of its creation would appear to have been attained; but the designs of divine wisdom are not so narrowly limited, and we find that in the formation of shells the wants of other animals, altogether alien to the first, have been kept in view. As if foreseeing that much time would elapse from the death of the mollusk to the decay of its hard calcareous fabric, and as if unwilling that such a relic should lie useless, the Creator has called into existence certain tribes of animals to possess them during this intermediate time. I do not here allude to a host of worms and zoophytes which find in their sinuous cavities a safe shelter to which they resort as occasion offers, but I mean certain crustaceans and worms whose organization makes it evident that they were created of purpose to become the possessors of those exuvial shells, without the protection of which they could not possibly exist. One tribe of the crustaceans are called Pea-crabs (Pinnotheres), which pass their lives enclosed within the shells of living bivalved mollusca, more especially of the mussels and pinnæ; and to enable them to do so with safety to themselves, and without inconvenience to their protectors, their bodies are made small, round, and flattened, and the crust is made thin, glassy, and of perfect smoothness, without angles or projecting spines. The other tribe are the soldier or hermit-lobsters (Paguri). The posterior half of the body of this race has no shelly crust, but is covered merely with a delicate transparent skin, and as a compensation for this defect, if we may so speak, it is instinctively thrust within some univalve turbinated shell large enough to

contain the whole lobster, which, in his borrowed panoply, now walks abroad in safety, careless of the wave and regardless of an enemy; for, on the least alarm, he retreats rapidly within his adopted house, where he is secure from all ordinary shocks and assailants. The small shells become the home of the young Paguri; but when the lobsters have grown too large to be contained easily in the cavity, they quit it to occupy a larger, and their combats with one another to obtain the shell of their choice has been a favourite theme with popular writers and voyagers, for they are very common on the shores of all countries.* That this connection between the lobster and the shell is not accidental but foreordained, is clear from the structure of the former: at the extremity of the tail there are some appendages curved, and otherwise fashioned, in a manner which shews that they were made to hold to the shell; and on that side of the posterior half of the body which is applied against the pillar of the shell, there is a series of similar appendages or claspers, which, let it be remarked, occur on that side only, while all other lobsters are symmetrical or alike on both halves. To these particulars permit me to add the following passage from a paper on the habits of Paguri by Mr. Broderip:—"In pursuing my inquiries upon this subject," he says, "I have been struck by two beautiful provisions in the animal œconomy of these Paguri. Their backs are towards the arch of the shell, and their well-armed nippers and first two pair of feet generally project beyond the mouth of it. Their two short pair of feet rest upon the polished surface of the columella, and the outer surface of their termination, especially that of the first pair, is most admirably rough-shod to give 'the soldier' a firm footing when he makes his sortie, or to add to the resistance of the crustaceous holders at the end of his tail when he is attacked and wishes to withdraw into his castle. On passing the finger downwards over the termination of the feet they feel smooth; but if the finger be passed upwards the roughness is instantly perceived. The same sort of structure (it is as rough as a file) is to be seen in the two smaller caudal holders. The second provision I observed in a very fine and large species of Pagurus from the Mauritius. Two specimens are in my possession; one of which is housed in a very large young shell of Pteroceras truncatum, the other (nearly a foot long) is naked, and on examining the under side of

* Our native Pagurus bernhardus, adapts itself readily to many kinds of shells, but it is asserted that some foreign Paguri use only certain species of univalves. Some small native Paguri, recently discovered, seem to be also limited in their choice.—See Bell's *Brit. Crustacea*, pp. 171—187.

the tail of this, a great number of transverse rows of acetabula are to be seen even without the aid of a glass. My friend, Dr. Bright, has another naked specimen in which the same formation, which must very much assist the hold of the Pagurus, is visible."* There is something so uncommon and wonderful in this adoption of the shell of one animal by another, to favour which even an anomalism of structure was requisite, that the great Swammerdam, familiar as he was with all the miraculous phenomena of insect life, could never credit the history, believing that the lobster was the true original tenant. "Hence it appears what an idle fable that is which is etablished even amongst those who study shell-fishes, when they shew some of the crab kind in their museums, adding at the same time, that they pass from one shell to another, devour the animals that lived in those shells, and keep them for their own habitations. They dignify them with sounding names and additions, as soldiers, hermits, and the like; and thus, having no experience, they commit gross errors, and deceive themselves as well as others with their idle imaginations."† It is, however, the very reverse of an idle fable; and here allow me to add that I know of no one fact which more directly negatives all the strange hypotheses which have been of late years broached relative to the capabilities of animals to alter their forms and go forward to perfectibility; for, assuredly, no animal coated, as the lobster is, with a crust fitted with the nicest adaptation would yearn to free itself of this mail and expose its thin skin to the rude elements; or, having done this folly, would not, were it able, by a continual desire and consequent reflux of its fluids, regenerate its own crust rather than thrust its naked tail, from race to race, into a shell which is comparatively a cumbersome appliance, and not more neatly fitted to its bulk than were the boots of the heavy dragoon to the uncalfed legs of the famous Goose Gibby!

The animal most nearly allied to the Hermit-lobster which uses a somewhat similar device is a native species of spider, whose operations I have had the pleasure of witnessing. This insect lives habitually in and under water; but having really no fellowship with that element, in which it can neither live nor breathe like aquatic animals, that it may pass its life there in a dry comfortable manner, it appropriates to its use the old shells of water-snails (Limnæus stagnalis). Entering the shell, the spider closes the aperture with a web or curtain of varnished silk, which repels the water and hinders its

* Zool. Journ. iv. 207. † Book of Nature, 66.

admission; she then fills her abode with atmospherical air, but how I am not able to say. The shell is sometimes found lying at the bottom of the pond, but, rendered buoyant by the air within, it often rises and floats on the surface, and the wily insect is in this manner carried within reach of her prey, who feel no alarm on the approach of what seems a snail! The stratagem reminds us of the sportsman, who, in some of the fenny counties of England, lies hidden in a shallow boat, and permits himself to be carried by the winds or current amid his unsuspecting game.*

There is a genus of naked worms (Siphunculus) which makes a similar use of dead molluscous shells. One species, discovered by Mr. Montagu, inhabits old worn specimens of the Strombus pespelicani and Turritella cornea, whose apertures it closes with sand cemented by a glairy secretion, leaving only a small circular hole sufficient for the protrusion of its long proboscis, but incapable of admitting any animal by which its safety can be endangered. Another species, common on our northern shores, takes possession of the common tooth-shell (Dentalium entalis), securing the aperture in the same manner; and there are foreign species which exhibit analogous artifices. Other soft worms and zoophytes (Cliona celata) penetrate the substance of shells, boring deep furrows in them, where they safely follow out their life and prescribed duty; and let it be remembered, that these worms are always constructed with a reference to the shells which they dig into: though the mollusk is independent of them, they, on the contrary, are entirely dependent on the mollusk.

There is not the same intimate dependence between some land-shells and some insects that appropriate them; but the instinct that leads the insects to this appropriation is worth noticing. Two nearly allied to the Bee form their nests in the deserted shells of snails; one of them (Osmya bicolor) apparently nidifies only in the Helix nemoralis, and the other (Osmya helicicola) most frequently in the Helix pomatia. Another insect, named Sopyga punctata, inhabits the same shells, and passes its two stages of metamorphoses in the cells of the Osmya.†

You might think me forgetful were I to conclude this letter without some mention of the Paper Nautilus or Argonaute, a shell familiar as the ornament of the chimney-piece,

* I may not find a fitter place than this to mention that the helmet of the frogs, in the War of the Frogs and Mice, is very cleverly shown by Menke to be the Limnæus stagnalis.—*Reports on Zoology*, p. 417. Lond. 1847.

† The Naturalist, No. iii. p. 144.

and as the original whence artists have derived many a pretty design for the car in which the sea-born Venus is made to ride the ocean:

> " A shell of ample size and light,
> As the pearly car of Amphitrite
> Which sportive dolphins drew."

For you must have read in some of our popular works, that the animal found in this shell has been supposed by many of our best naturalists to be, not its own fabricator and rightful owner, but an alien and vagrant cephalopod, which has had the good taste to select it for its house and canoe, probably after having made a meal of its hypothetical inhabitant. This opinion, which has had advocates even from the days of Aristotle, has been maintained with much ingenious argument, and some continue to think the question unsettled;* but I must confess that the perusal of Madame

* Of this number is Mr. J. E. Gray, who, in a very recent publication, has summed up the most important arguments in favour of the animal's parasitism in the following passage:—" The female Ocythoes are often found in the shell of the Argonaut, and have hence been supposed to form these shells, and as yet no other animal has been found inhabiting them; but there are several reasons for believing that the Ocythoe is only a parasite adapted by its form to live in such shells, as the web of the arms is used by the animal to embrace the shell and keep it in its right position on the body. Unlike all other mollusca, which form the shell they inhabit: First, the Ocythoe is not attached to the shell by any muscle, nor has it any muscle, like the bone-bearing cuttle-fish, formed for the purpose of attaching the body to its internal shell. Secondly, the animal, when alive, does not fit the shell; so that the shell cannot have been moulded on its body, as in other mollusca. Thirdly, the skin of the Ocythoe is of the same texture and appearance as in the other naked cephalopoda; and the presence of sand between the shell and the body appears to cause no uneasiness to the animal, as it does in all other shell-bearing mollusca, where the animal immediately rids itself of the irritation so caused by covering the sand, &c., with a calcareous coat. The animals found in these shells are always female, and the apex of the shell is filled with very small eggs; while from the large size of the young shell, which is seen on the apex of the true Argonaut, we should expect the animal which formed that shell to have a large egg; for, though the eggs of mollusca are enlarged during the hatching, they are not, in any case I have observed, so much enlarged as to have such a shell.

" It is supposed by the persons who believe that the shell is formed by the Ocythoe, that it is formed and mended when broken by the expanded ends of the upper arms, which embrace the outer surface of the shell, and thus keep it on the body of the animal.

" Cranch and Adams, who have seen these animals alive, state that they leave the shell when they are frightened, and that they cannot recover their position in the shell after they have thus left it.

" Mr. Adams regards the Argonaut shell as a nest formed by the female to contain her eggs; so, if this is correct, they can scarcely be compared to other shells. He regards them as similar to the cartilaginous cases which Murices and other zoophagous mollusca form to contain their eggs; but

Power's experiments, supported as they are in the main by those of Sander Rang; and a study of Professor Owen's ably reasoned report on them, * and on the opposing facts, have convinced me of its erroneousness; and now I believe the shell and the cephalopod to be one species and individual, whose curious history will occupy us in a future letter.

they have no apparent analogy to those bodies, which are secreted by the oviduct as the eggs are deposited.

"These various views shew that the origin of the shell is not yet distinctly settled."—*Catalogue of Cephalopoda in Brit. Mus.* 28.

* The reader will find the various papers alluded to in the first and third volumes of Charlesworth's Mag. of Nat. History, and in the Notices of Communications to the British Association for the Advancement of Science, 1844, p. 74.

LETTER VI.

THE MOLLUSCA CONSIDERED IN THEIR RELATIONS TO INORGANICAL OR DEAD MATTER.

In the preceding letters, I have illustrated, at some length, the relations in which the mollusca stand to man and other animals, and you are satisfied that even in that view they are worthy our attention. I now proceed to indicate more briefly the results they operate on dead and inorganic matter, their share of influence in the construction of the globe as it now exists, and in those changes which are gradually altering its present aspects.

In all countries, but especially in those where a warm or tropical temperature clothes the surface with forests, which extend unmeasured shades along the banks of their mighty rivers, an inconceivable quantity of trees are annually floated to the ocean during the rainy season. When, by any cause, a portion of these has been stopped in its descent, the course of the river is turned aside, and an island has been the consequence ; and there can be little doubt, that in the lapse of ages even the deep sea would labour under the load—bays would be filled, and the mouths of rivers and harbours obstructed—for wood, when entirely submerged, is almost indestructible under the mere influence of water. But the Teredo, and one or two allied mollusks, have received their commission : under their augers, worked by an instinct which allows of no repose, and no misapplication of their powers, the timber is drilled through, crumbled down, and removed as fast as it is supplied. "The seaman," to adopt the rather pompous language of a very excellent author, "as he beholds the ruin before him, vents his spleen against the little tribes that have produced it, and denounces them as the most mischievous vermin in the ocean. But a tornado arises, the strength of the whirlwind is abroad, the clouds pour down a deluge over the mountains, and whole forests fall prostrate before its fury. Down rolls the gathering wreck towards the deep, and blocks up the mouth of that very creek the seaman has entered, and where he now finds himself in a state of captivity. How shall he extricate himself from his imprisonment ? an imprisonment as rigid as that of the Baltic in

the winter season. But the hosts of the Teredo are in motion: thousands of little augers are applied to the floating barrier, and attack it in every direction. It is perforated, it is lightened, it becomes weak; it is dispersed, or precipitated to the bottom; and what man could not effect, is the work of a worm. Thus it is that nothing is made in vain; and that, in physics, as well as in morals, although evil is intermingled with good, the good ever maintains a predominancy."*

The Pholades, the Saxicavæ, and Lithodomi, with habits analogous to the Teredo, excavate their cells mostly in limestone rocks and indurated clay, and in this manner contribute to alter the configuration of the shores.† If you confine your attention to the operations merely of those species which are found on the coasts of Britain, and if, as one is apt to do, you measure their influence by those which are working under your own observation, that influence you will infer to be very slight; but it is by slow and imperceptible steps that all the great changes in the material world are effected; and to do justice to the lithophagous mollusca, you must multiply the extent of their disintegrating excavations during the brief span of your own life by the centuries of the world's age, and your own little domain by the millions of miles which engirdle the sea, along which their colonies are spread. Their disintegrating influence must have been at all times, and must continue to be, considerable; for it is not merely by their own excavations that the opposing rocks are reduced, but through them water is admitted into their interior, and aided by its macerations—its varying expansions under various temperatures—the ceaseless wearing away of this additional agent, while it flows or percolates through new channels opened to its access—the rock is speedily rubbed down into an impalpable dust, or broken up into loose fragments. Consider the result: the outline of the shore is altered, a barrier to the tide removed, and perhaps some inroad is made on the soil; but the limestone thus triturated to powder is carried off with the ocean wave, and, in a course which it is not difficult to follow, becomes absorbed by the myriads of animals of every class, which again consolidate and convert it into coral vegetations, crusts, and shells,—to become in their turn, at some distant date, the foundation of a barrier of a future

* Good's Book of Nature, i. 265. To the same purport see Sellius de Tered. Mar. 175.

† "Perforat—Teredo ligna, ut destruantur; quemadmodum Pholades, et Mytili lithophagi petras, ut solvantur." Linn. Syst. 1069.

shore. Such, to adopt the simile of the poet, is the rotation of the unwearied wheel which Nature rides upon!

I am not, however, one of that class who unhesitatingly maintain that from such and similar sources the mollusca derive the whole of the calcareous materials of their shells. By the mechanical operation of the waters upon limestone rocks, and by the chemical action of carbonic acid, a large portion of lime in a state of very minute division, or in solution, is carried by rivers into lakes and seas, a portion which is greatly increased there by the lithophagous mollusca, by the action of the tides, and by the trituration of dead shells and coral. Hence the source, many say, of the lime which the mollusca require: it is imbibed with their food and with their drink, in small quantities at a time it is true, but sufficient to supply materials for the very slow and imperceptible excretion of the shell. Now I doubt this. The analysis of sea-water gives us the exact quantity of lime supplied by these extrinsic agencies; and in a pint from the Firth of Forth, Dr. Murray finds only five grains and a fraction of muriate of lime,*—a proportion which appears to me too small for the necessary demands of the hosts of animals in whose composition lime enters as an ingredient. I am therefore inclined to believe, for it becomes us to speak warily on such a question, and the opinion is very unfashionable, that the testaceous mollusca, in common with other animals, have really the power, not merely of separating lime from its combinations and mixtures, but can produce it by the powers of vitality, from elements hitherto considered as simple.† There is a natural repugnance to the admission of an hypothesis like this, which assumes the existence of almost a creative power in animal bodies, and its necessity has been denied. Shells, they tell us truly, are thicker and coarser in the lakes and ponds of a limestone district than of districts whose rocks belong to other formations; and land-shells are much more abundant in the former than in the latter, and whence this difference in the quality of the shell, and the productiveness of the race, but from the difference in the supply of this material? Where it is procured in scantiness, there the animals are few in numbers, and the shell is thin and clear. Following the same line of argument they have asserted that the edible snail, which, under ordinary circumstances, forms a calcareous operculum previously to hybernation, is unable to make anything more than a membranous substitute "when

* Syst. of Chemistry, iii. 696.

† Dr. Drummond entertains the same opinion.—*Letters to a Young Naturalist*, p. 211.

deprived of nourishment." The proofs are evidently defective, for we admit that when the foreign or exterior supply of lime is abundant the secretion of it will be proportional; and when the system is weakened by a deficiency of food, it seems unreasonable to demand of it the full performance of a function which it could easily perform when in health and vigour. It is, moreover, notorious that the testaceous mollusca are to be found in countries where there is no limestone; and that lime is not necessary to the edible snail, in order to the perfect formation of the operculum, has been proved by Mr. Bell,—many snails in his possession having formed that part, though during the whole summer they had no access to any preparation of that earth.* Let me also remind you that the fœtus of every testaceous mollusk, while still within the egg, is covered with a shell like its parent; and in the larger species this shell will have attained a considerable bulk and consistency ere the time of its exclusion arrives. Now whence has this fœtus obtained the calcareous constituents of its shell, if we will not allow of its formation by the fœtus itself? The latter has tasted no food, drunk no impregnated water, no lime is to be detected in the jelly which immediately envelops it, and the access of water is carefully excluded by certain contrivances hereafter to be described. I am not going from this to assert that any organic agent has the power either of creating material elements, or of changing one such element into another;† but surely it may not be venturing too far in conjecture to imagine that lime or calcium may prove to be other than an elementary body. "It is now ascertained," says Mr. Bakewell, "that lime and the other earths are compounds of oxygen united with metallic bases; and the brilliant discoveries of Sir H. Davy respecting the metallic nature of ammonia, would lead to the conclusion, that the metallic bases of all the alkalies and alkaline earths, which have many properties in common, may, like ammonia, be compounds of hydrogen and azote, but differently combined. Now it is well known that hydrogen and azote, which exist as elementary constituent parts of almost all animal substances, may be derived from water and the atmosphere; and should the compound nature of the metallic bases of the earths be ascertained, the formation of lime by animal secretion will admit of an easy explanation."‡

Were it proved that all limestone is an animal production,

* Zool. Journ. i. 96—97.

† Prout's Bridgew. Treat. 431.

‡ Introd. to Geology, 110.

as Linnæus and many geologists have maintained,* the conclusion that carbonate of lime is formed in the body of the mollusks, independent of all exterior source, would necessarily flow from the axiom; but the opinion has been contested of late, and, indeed, rendered untenable. Still it seems to be almost demonstrable that extensive deep calcareous strata which exist in different parts of the world, have originated from the detritus or decomposition of shells; and when we take into consideration the great extent of these formations, and the prodigious quantity of lime which enters into them, we are drawn to coincide with Dr. Bostock, one of the best and most cautious physiologists of the age, that the opinion of its having been a mere excretion of matter which had passed through the system, though it accords best with our ideas of the usual operations of nature, "is rendered improbable from the immense quantity of matter which the animals must have appropriated to themselves; and it is not very easy to conceive in what state the lime could have existed previous to its reception into their system."†

In whichever way we decide this interesting question, whether the testaceous mollusca merely excrete and reconsolidate the dissolved lime, or have the power of forming it from materials in which our chemistry has hitherto detected none, it little affects our estimate of their influence in the construction of the globe. Called into life at an early period of the world's age, among the first indeed of living beings which broke the dead rest and stillness of its infancy, they immediately began their appointed work, and multiplying in myriads which no numbers can reckon up, their shells became the foundation, and if not the chief, certainly a very material part of enormous strata and chains of rocks; nor have they ceased, through all the intermediate ages, to play a preponderating part in every revolution which has occurred. In the earliest fossiliferous rocks we find buried the remains of vast numbers of brachiopods (which appear, indeed, to have been the principal tenants of that primæval sea), of

* "If Saussure," says Dr. Clarke, "had not discovered limestone lying beneath rocks of the most ancient formation, the French would long ago have established a theory that all the strata of carbonated lime, upon the surface of the globe, have resulted from the decomposition of animal matter deposited during a series of ages." — Travels, i. 624—626. 4to.—See also Macculloch's Geology, ii. 414; and the article "Organic Remains" in Brewster's Edinb. Encyclop. xv. 705, 706.

† Syst. of Physiology, ii. 384—and particularly the note at p. 386. See also Thomson's Hist. Roy. Society, 211, 212. De La Beche's Geog. Manual, 452, 453.

many pteropods of larger bulk than those now existing, of the chambered shells of many singular cephalopods (Orthoceratites, &c.), and the shells of some gasteropod and bivalved mollusca. Ascending to the carboniferous formations of this silurian epoch, the molluscan fossils thicken upon us. Brachiopods abound under novel forms; a larger number of gasteropods and of ordinary bivalves have appeared to aid in the great work; "but the cephalopodous inhabitants of the seas during the carboniferous period were still the most important and the most numerous of the molluscous animals; and they included not only the straight shells of Orthoceratites, but a large number of spirally twisted species, bearing a somewhat different relation to the nautilus. The most important are called Goniatites." * It is from these strata that lime is principally worked; and in the marble of which your chimney-piece is made, you may trace the figures of shells that have been pictured there by no sportive freaks of the formative powers of nature, nor by a spontaneous vegetation, as philosophy once dreamed, but that are the real remains of living creatures which "have put off flesh and blood, and are become immutable."—Ascending to the middle epoch, we find, indeed, the former races to have disappeared, but their places are fully occupied by others approximating nigher in character to those of existing seas, "without any of the species being identical, and with little approach even to existing genera." A very large number were among the common tenants of the lias, both brachiopods and bivalved and univalved mollusks; and another large and important group called Ammonites, related to the existing Nautilus. The Belemnite, which was a naked cephalopod allied to the Sepia, was also a common animal, and, with the Ammonites, so thronged some parts of the sea that complete strata seem to have been formed of their remains.—In the oolitic seas mollusca swarm even more abundantly: some Terebratulæ, in certain localities, lived in beds as oysters now do almost to the exclusion of other animals; the Ammonite was scarcely less abundant than in the preceding period; and the Belemnite now occurs in the highest perfection, varying in size from specimens not an inch long to others measuring upwards of a foot.—The succeeding cretaceous period owes not less to its molluscan tenants, and their fossils truly indicate their influence. Bivalved and univalved genera thronged the waters; and the

* Ansted's Ancient World, 96. In this popular and pleasant volume, the student will find the successive creations of the mollusca carefully indicated, and good figures of the most remarkable and characteristic species.

cephalopods, ere long destined to be dismissed from among the workers which were operating so assiduously to fit this globe for man's tenancy, "seem to have expanded into a vast multitude of strange forms before becoming finally extinct."—We step on into the modern epoch; and there, too, the mollusca accompany us—different, indeed, in species from all that had preceded them, but alike in this work of contribution to our earth's perfection. The Ammonites have died out, and their place and purpose is occupied and fulfilled by carnivorous gasteropods, in their spiral shells, created in the most remarkable profusion. The Nummulites—small shells of doubtful classification—also abound, and are so incredibly multitudinous in some localities that rocks are made up of them. "Other smaller foraminiferous shells have built great masses of the limestone of this period." They enter so largely into the composition of the stones of which Paris is built, that it may be said without exaggeration that that great city is built of shells.*—This very general statement is sufficient for the purpose in view, of indicating the vast influence the mollusca have had in their capacity as assistant-architects of our world; but to make their remains subservient to geology, the conchologist has to go more narrowly to work,—he has to ascertain the species which occur in every layer, if I may so speak, of every strata; to mark those which are peculiar to each; to note the variations they have undergone in their transition from one formation to another; the times of their creation—of their chief predominance—of their decay and extinction; and to specify what new forms come to supply the place of those which are about to disappear, or which have been erased from the volume of living entities. From such researches, which have been conducted with a zeal and ability that cannot be too highly praised, geologists have borrowed largely; and though the value of the evidence which fossil shells afford in unravelling the mutations of the earth is variously estimated, yet it seems agreed on all hands that it would be as wise for the historian in tracing the history and manners of an ancient people to neglect their medals and their monuments, as for the geologist to overlook the light thrown over his antiquarian researches by these medals of the ancient world. "The different series of formations," says the Rev. Mr. Conybeare, "differ very materially in the species of organic remains which they include, and by which they are, therefore, said to be characterised. The species frequently vary from form-

* Desc. de Coq. car. des Terrains, 253.—Dr. J. P. Smith's Script. Geol. 98.

ation to formation, so that they have been said, almost without exaggeration, to be as regularly disposed in the geological formations as in the drawers of a well-arranged museum; hence if the fossils of any given locality be known, we may securely pronounce as to its geological formation, and *vice versâ*."*

Mr. Lyell has divided the tertiary formations into three periods; and it has been ascertained by Deshayes, that as we proceed from the lowest of these to the most recent, there is a gradually increasing approximation to the existing forms of nature: in the lowest, or eocene, there are only three testaceous mollusks in the hundred identical with existing species; in the mid, or meiocene, there are nineteen; but in the uppermost, or pleiocene, the proportion is upwards of a half, or fifty-two per cent. During this latest period, however, the mollusks continued to effect very considerable deposits, less in extent, it may be admitted, than in previous epochs when the secondary and carboniferous limestones were formed, but still sufficient to vindicate their claims to be, among animated beings, the most influential of any, excepting zoophytes, in altering the relation between sea and land. Examples of these deposits abound in the north and south of Europe in general, in Asia and Africa, and in New Holland; but we select one only as an illustration of our position.

In France, in the neighbourhood of Touraine, there is a continuous bed of broken shells, of about nine ancient square leagues in superficial extent, and at least twenty feet in thickness: the whole mass of shells is estimated at 170 millions of cubic tons!† Such facts seem to warrant the inference, that the living mollusks continue to be powerful cooperative agents in bringing about those changes which slowly and imperceptibly are imprinting an altered character on the features of our earth; and it is so. In Europe there are everywhere remarkable beds of shell-marl, abounding with the remains of lacustrine mollusca, which certainly constitute a very material part of its bulk; and by these depositions lakes and marshes have been filled up to a great extent. Beaches composed of dead sea-shells are

* West of Eng. Journ. i. 3.—"Conchology, studied in a logical manner in its various relations both to zoology and geology, may become a powerful means of bringing this latter science to perfection. It is even allowable, in the present day, to anticipate the time when Conchology shall arrive at questions which relate to the general physics of the terrestrial globe, and furnish us with the necessary materials for their solution."—Deshayes, *Mag. Nat. Hist.* n. s. i. 9.

† Malté-Brun's Geog. ii. 268—272.—Jameson in Brewster's Edinb. Encyclop. xv. 735.

found scattered through the world, the mass being the remains of some gregarious species, such as the oysters, which the sea has left uncovered in its retreat, or which, by their increase near the mouths of rivers, have forced the stream to seek another entrance into the ocean. For proofs of their efficacy to this purpose, we need not travel abroad, though undoubtedly the more remarkable of them are, as you might anticipate, to be found in warm and tropical climates, where life is more prolific than in the moderate temperature of Europe, and productive of larger growths. In Senegal, Adanson mentions that in the tide-way of the Del, not far from the mouth of the Niger, the village of Del is built on the extremity of a bank of shells, which extends nearly a league to the north; all this enormous bank being solely composed of the valves of the tree-oyster that had once lived there pendant from the roots of the mangol-trees, but had been left dry by a change in the course of the river, that change effected by their own natural increase.* The same traveller describes another bank formed in a similar manner, by the same species of oyster, which is of still greater extent, and gives name to a district of Senegal—"le quartier de la Chaux,"—because the whole country is thence furnished with all its lime.† America supplies us with some remarkable examples of the same kind, where at the mouth of many of its large rivers, a little elevated above the tide, there are extensive beds of the Ostrea virginica mixed with some littoral shells in a sub-fossil state.‡ Anastasia Island, upon the eastern coast of Florida, which is about ten or twelve miles long, and one and a half broad, "is composed of horizontal layers of a

* Voy. au Sénégal, 128. † Ibid. 147.

‡ Dr. Rogers adds—"The position in which these beds of shells are invariably seen, is upon the low level plains adjacent to the tide-creeks of our rivers, where they appear to have dwelt in colonies in the sheltered bays at a time when these plains were at a small depth beneath the water, and to have been lifted with them by, perhaps, the last shock which has changed the level of the coast. These shells, in a sub-fossil state, occur in Cumberland county, New Jersey, on the bank of Stow Creek, at Egg Harbour, on the Severn, at Euston, in Maryland; again, upon the York River in Virginia, and indeed upon many others of the southern rivers. They occur at the mouth of the Potomac, resting upon the beds of marine shells, which were originally described in the Journal of the Academy of Natural Sciences, by Mr. Conrad, and considered by him as referable to the newest of our fossiliferous formations. In the same locality, these beds of fossil Ostrea virginica are seen to be covered by the diluvium, so that there can be no question of their origin having been during the latest stage, as it were, of the tertiary period, and not connected, as imagined by the vulgar, with human agency."—*Fourth Report of Brit. Assoc.* 17.—See also Bosc's *Coquil.* ii. 295.

semi-indurated rock, consisting wholly of fragments of shells, belonging, as far as examined, almost, though not exclusively, to species inhabiting the adjoining coast." There are similar islands and beaches on the coasts of Georgia and Florida; and Dr. Rogers believes, that most of the other sand beaches and islands which lie along the coast of North America, as far as Long Island, have the same origin. We do not say that these shells, by their aggregation, gave of themselves origin to the islands in question, but it is very evident that they have materially contributed to it: probably the layers of shell-rock are the result of vast colonies of bivalve and other shell-fish which had settled on sand-banks, and been lifted up afterwards above the waters by the agency of earthquakes. A deposit, composed entirely of two existing shells, in a subfossil state, the Cyrena carolinensis, and more especially the Rangia cyrenoides of Des Moulins, extends along the whole shore of the Gulf of Mexico from Pensacola to Franklin in Louisiana, bends round Mobile Bay, Lake Poutchantrain, and ranges across the delta of the Mississippi immediately above its marshes, a total distance of nearly three hundred miles, and probably much further! It is remarkable that the shells "occur in beds with scarcely any admixture of sand or earth, and they are consequently found extremely useful in repairing roads, and paving the streets of the city. They are dug from the surface of the soil, both on the main shore and the islands of the bay. These deposits border the bays of the Gulf of Mexico between Mobile and New Orleans, and they occur in the vicinity of Franklin, Louisiana. The Ohandeleur Isles, between Mobile Bay and the delta of the Mississippi, consist of deposits of these shells covered by a fertile soil. The Rangia lives in vast numbers in the extensive flats below Mobile, burrowing three or four inches beneath the surface of the sand, in which numerous depressions indicate where they are to be found."*

There is reason, therefore, to believe that the exuvial coverings of the mollusca continue to be heaped up in the dark unfathomed caves of ocean, to become, at some future period, and under the pressure and influence of conjectural agencies, the material constituents of calcareous banks or

* Fourth Report of Brit. Association, 14, 30. Near Valparaiso, there are great beds of shells, which are elevated some yards above the level of the sea. "They nearly all consist of one species of Erycina; and these shells at the present day live together in great numbers on the sandy flats. So wonderfully numerous are those forming the beds, that for years they have been quarried and burnt for the lime, with which the large town of Valparaiso is supplied."— C. Darwin, *Voy. of Adv. and Beagle*, iii. 310.—See also vol. ii. p. 421.

strata; although we will concede that the gregarious species are fewer, and perhaps less accumulative, than they were in the primæval seas, which some geologists have imagined were overcharged with carbonate of lime, affording a more abundant supply of matter to the shell-fish, and a consequent greater multiplication of them. But the introduction of Man on the scene has proved a more certain, and a very powerful check to the accumulative results of the present races of molluscans; for the species which are most conducive to the process, he dredges up in millions, to be used for food, for bait, for ornament, and for the purpose of conversion into lime and manure. Reflect for a moment, and you will readily admit how widely and surely this check operates. How countless are the loads of oysters alone which are annually dredged up on our coast, and on every habitable shore! multiply these by some two or three thousands of years; calculate their increase from one generation to another (which would have gone on, in a more than geometrical progression, had they been left undisturbed in their native haunts), and then you may estimate the depth and width of their banks which would have covered the sea's bottom. And this is to take one species only into the calculation; but, in fact, no mollusk, which occurs in sufficient numbers to alter it materially, is left to its natural spread and increase, for what he cannot use as food or bait, man burns into lime, or strews on his land as manure,—a purpose which he has ascertained they answer admirably well, their superiority to common lime depending doubtless on the animal matter which enters into their composition.

Nor are you to underrate the numbers used in this way, for they are incalculable. In our own land, indeed, where limestone is abundant, and the supply of recent shells precarious and limited, we reckon not much upon them*; but the greater part of the lime used in America, for agricultural and architectural purposes, is made of calcined shells. The

* In 1662, Mr. Ray saw the people on the Welsh coast "burning cockle-shells, thereof to make lime. The manner thus. They make an hole in the ground, therein they put furze, upon that wood, upon the wood small stone coal, and then a layer of cockle-shells, and so shells and coals. s. s. s., and then put fire to them, these burnt, make excellent lime."—*Sel. Rem.* 245.—Lister asserts, that in his time, living mussels were extensively used in manuring the fields in Lancashire.—*Hist. An. Ang.* 183. Numerous examples of their application in this manner might be specified, but the most remarkable, and the only one I shall instance here, is contained in the Phil. Trans. for 1708, and communicated to the Royal Society by the Archbishop of Dublin.—"Marl is not used in the north parts of Ireland; but about the seaside the great manure is shells: towards the eastern part

inhabitants of the maritime parts of Africa, of India, China,* and of New Holland, are equally dependent on the same source for their supply of this necessary article,—hence the consumption of shells over this the greater half of the globe must be enormous, and must retard, if not entirely nullify, their accumulation into banks and beaches. To restore the molluscans to their pristine influence in the mutations of the earth's surface, it would be necessary to render it first unfit for the residence of man, or that he should grant them the petition of the dead—"leave me, leave me to repose!"

I here conclude what I had to tell you in relation to the economy and uses of the mollusca. In my next, my endeavour shall be to give you a view of the system which Cuvier has invented for their classification, when we shall be prepared to enter on what relates to their structure and physiology.

of the bay of Londonderry, commonly called Loughfoyle, lie several eminences, that hardly appear at low-water; these consist of shells of sea-fish of all sorts, more particularly of periwinkles, cockles, limpets, &c. The countrymen come with boats at low-water, and carry loads of these shells away; they leave them in heaps on the shore, and there let them lie till they drain and dry, to render them lighter for carriage; they then carry them by boats as far as the river will permit, and then in sacks on horses, perhaps six or seven miles into the country. They allow sometimes forty, but mostly eighty barrels to an acre. These shells agree with boggy, heathy, clayey, wet, or stiff land, but not with sandy." "The manure continues so long, that none can determine the time of its duration. The reason of which seems to be, that these shells dissolve every year a little, till they be all spent, which requires a considerable time; whereas, lime, &c. operates all in a manner at once; but it is to be observed, that in six or seven years the ground grows so mellow, that the corn on it grows rank and runs out in straw to such a length that it cannot support itself, and then the land must be suffered to lie a year or two, that the fermentation may abate a little and the clods harden, and then it will bear as long again, and continue to do so, with the like intermissions for twenty or thirty years. In the years in which the land is not ploughed, it bears a fine grass, mixed with daisies in abundance, and it is pleasant to see a steep high mountain, that a few years before was all black with heath, on a sudden look white with daisies and flowers. It fines the grass, but makes it short, though thick."—"Some thousands of acres have been improved by the shells, and that which formerly was not worth a groat per acre, is now worth four shillings; they have in many places thus improved the very mountains, that before were mere turf bogs."—*Phil. Trans. abridg.* v. 404—5. See also *Phil. Trans. abridg.* ix. 82.

On the use of shells in agriculture in America, see Gould's Report Invert. Massachus. 361.

* The Chinese "not only burn lime from the oyster-shells, but likewise make use of the largest in their buildings, instead of bricks."—Osbeck's *Voy. to China*, ii. 317. See also Staunton's *Embassy*, iii. 432.

LETTER VII.

AN EXPOSITION OF CUVIER'S ARRANGEMENT OF MOLLUSCOUS ANIMALS.

I HAVE already mentioned that Cuvier was the first who grouped together the animals to which the name of Molluscous is now properly restricted. Previous to the publication of his memoir on the classification of avertebrate animals in the year 1795, the Mollusca were intermingled with worms and with zoophytes, while a great number of them stood detached from their allies under the ordinal designation Testacea, merely because they were enclosed in hard calcareous shells,—the knowledge of the inferior tribes being then too little advanced to admit of the application of any characters but those that were derived from exterior form and consistence. By his numerous careful dissections, Cuvier was early enabled to detect and appreciate the unnaturalness of the prevalent systems; and when his labours had convinced him that their overthrow was necessary to the progress of science, they had at the same time furnished him with the materials out of which he sought to erect a new system, which has been of incalculable advantage to scientific conchology, and which remains untouched in all its grand lineaments, though his successors have certainly improved and worked out many of the minor details. These we shall have a future opportunity of discussing. I mean at present to give you an outline of the original as it came from its author's last revision, without note or comment; and when you are made aware that this great naturalist continued to regard it as one of the principal works on which his fame might safely rest, and watched it with a degree of parental jealousy, unwilling that the parentage should be either doubted or divided, you can have no need of being urged to make yourself its master. "It is well known," Cuvier himself tells us, * "how much care and time I have devoted to the anatomy of the mollusca in general, and in particular to the knowledge of the naked mollusca. The determination of the class, its principal divisions and subdivisions, all repose upon my proper observations; for the

* Règne Animal, tom. i. pref. xxvi. Paris, 1829.

magnificent work of M. Poli aided me no further than by some descriptions and some anatomies useful to my end, and these were confined to the multivalves and bivalves. I have verified all the facts which that able anatomist has furnished me; and, as I think, have determined with more accuracy the functions of some of the organs. I have also sought to characterize the animals to which the principal forms of shells belong, and to classify these in accordance with the organization of their inhabitants, leaving the ulterior divisions of them into genera and subgenera to those who devote themselves in particular to this work."

According to Cuvier there appear to be four general plans or models, if we may so speak, after which all animals seem to have been created. The variations superinduced on these plans may at a first glance seem considerable, and have, indeed, properly given rise to certain divisions in each of them; but by whatever name we designate these—classes, or orders, or legions—a close analysis of their organism demonstrates that the variation has been the result not of any change in the essence of the type, but of a slight or graduated modification of some one of the organic systems,—of the motive organs, of the nervous or circulating apparatus,—to which some parts, not inconsistent with the model, have been added or subtracted. Now, under the second of these four plans (sub-kingdoms) are reduced all the creatures to which the name of mollusca is assigned. The essential character lies in the peculiar arrangement of their nervous system, which consists not of a medullary ganglionated chord, but of some ganglions scattered, as it were, irregularly through the body, and from which nerves issue to its various parts. Hence the mollusca are less symmetrical in general than any other class of beings;* hence also the poverty of their instinctive faculties, and the deficiency of their muscular activity, for in these respects they are decidedly inferior to insects and annulose worms, and scarcely superior to the radiated animals. They have no skeleton nor vertebral column, so that the muscles are inserted to the skin, which forms a soft envelope contractile in every direction, and in or upon which are generated, in very many species, hard calcareous plates called shells—analogous, in the opinion of Cuvier, to the

* "Le corps tend toujours à se composer de parties binaires placées symétriquement des deux côtés d'un plan médian; mais cette symétrie n'est jamais complête, et ce plan, au lieu de se développer suivant une ligne droite, tend à décrire une courbe. Il en résulte que d'ordinaire la bouche et l'anus sont plus ou moins rapprochés, et que le corps, considéré dans son ensemble, présente en général un aspect plus ou moins difforme."—Milne Edwards, *Elem. de Zoologie*, iv. 237.

corpus mucosum of vertebrates. This muscular envelope contains the viscera, among which the nervous system lies unseparated, the principal ganglion or brain, as some call it, being placed under the gullet and encircling it with a filament as with a collar. Of the proper senses the mollusca possess those of taste and sight only, and the latter often fails. A single class has organs of hearing.* There is in all a complete system for the circulation of a white serous blood; and respiration is performed by special organs. The organs of digestion, and of the secretions, are nearly as complicated as they are in the vertebrated animals, and not less remarkable for their variety and curious adaptations. Such are the leading characters of the mollusca; and although this type of organization is not distinctly revealed by a very uniform correspondency between it and exterior configuration, yet there is such a degree of harmony and mutual dependency between the inner anatomy and the outward show, that only a little experience in their investigation is wanting to make us perceive and acknowledge it.

The mollusca defined in this general manner form a sub-kingdom, which is next divided into six classes,† their distinctions being founded on modifications of the organs of progression. For reasons already assigned one of these classes (Cirrhopods) is now considered as properly pertaining to the annulose sub-kingdom, and the five remaining may be shortly characterized as follows:

I. Cephalopods.—Body enclosed in a muscular sac containing the branchiæ, and open superiorly, where the head projects. This is well developed, and is surmounted with a circle of eight or ten subulate cotyligerous appendages (feet) subservient to progression and the capture of their prey.

II. Pteropods.—Body not sacciform; the head has no appendages, or only very small ones; the principal organs of locomotion are two wings, or compressed fins, situated at the sides of the neck, and which, in many species, perform the function of branchiæ.

III. Gasteropods.—These are also cephalous, but less distinctly so than the preceding: they crawl on the belly or on a fleshy flattened disk, which is sometimes, though very rarely, compressed into the form of a fin, different, however, from those of the Pteropods, and distinguished by its ventral position.

IV. Acephales.—Headless mollusca in which the mouth lies concealed in the base of the mantle, which also envelopes

* It will be remembered that I am almost translating from Cuvier. The sense of hearing is not so limited in the class.

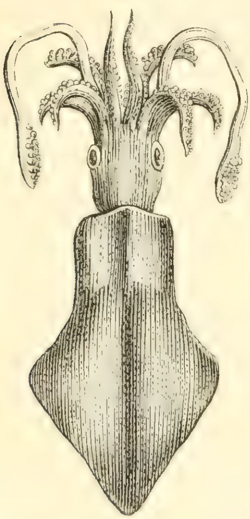
† Règ. Animal, iii. 6, 7.

the branchiæ and viscera. The mantle is open, in some genera, along its entire outline, when it forms two distinct compressed lobes; in others, it is open at its two extremities only; and, in others, the apertures are confined to one end.

V. BRACHIOPODS.—This class embraces the mollusca which, enclosed likewise in a mantle, and without any distinct head, have a pair of labial fleshy or membranous arms fringed with cilia of the same nature.

The first class or CEPHALOPODS comprises only one order (which it was therefore unnecessary to name), divided into genera, of the same value as the families of subsequent systematists, from the character of the shell. The typical genus —the Sepiæ—has no outer shell, excepting in the instance of the Argonauta, the cuttle of which Cuvier regarded as its proper fabricator; but the greater number of the other cuttle fish have an interior lamellated cellular, or sometimes horny, plate, formed in a peculiar cavity in the back. This genus embraces the Octopus or Polypus of the ancients; the Loligo (Fig. 12), or Calamary, which have two additional arms longer than the proper feet; and the Sepia, properly so called. The Nautilus, embracing all the spirally intorted many-chambered shells, is the second genus, of which the N. pompilius is the most familiar and characteristic exemplar. The third is the Belemnites,—conical straight multilocular fossils of a very singular structure, which decides them to have been the internal supports of probably the most extraordinary constituents of the class in an epoch of foregone time when all was strange; and now they appear to us anomalous and monstrous. It is upon well-grounded conjectures that the fossil Ammonites are also located here, distinguished from the Nautilus by the partitions between the chambers, which, instead of being plain or simply concave, are angulated, sometimes wavy, but more commonly laciniated on their margins, so as to resemble the crisping of the leaves of the acanthus.* They are believed to have been likewise

Fig. 12.



* The inner structure is chambered, but the diaphragms, or partitions

internal shells; and their animals to have had the power of rising from the bottom, and of sailing on the surface of their native seas. Their remains swarm in the secondary calcareous strata, some of them not larger than a bean, while others equal a small chariot-wheel in size; and being subject to many variations in the form of their spires, naturalists have availed themselves of these as the means of collecting them into small groups for accurate examination. But in this tendency to variety, they probably yield to the genus which follows, the Camerines of Bruguière or Nummulites of Lamarck,—fossils, distinguished some of them by their lenticular shape, without any perceptible external aperture, while the inner spiral cavity is divided by septa into an infinity of little chambers, which do not communicate together by means of a syphon, as is the case in the Belemnites and Ammonites.—The patient and laborious researches undertaken successively by Bianchi, Soldani, Fichtel and Moll, and Alc. d'Orbigny, have discovered an astonishing number of chambered shells which, like the Nummulites, have no siphon communicating between the chambers, and which are extremely small, often indeed invisible, excepting through the microscope. They vary, too, very remarkably in their figure, their armature and sculpture, and in the number and relative position of their chambers. Most of them are found in a fossil state in the sandy strata of many countries; but a considerable number are recent, living in the sea among sand, sea-weed, or corallines. Of one or two of these the animal has been examined, and it appears to have a little oblong body crowned by many reddish tentacula—an observation which, joined to the chambered structure of the shell, has caused them to be arranged as a family among the Cephalopods; but the classification cannot be regarded as settled until further investigations have more accurately informed us on their anatomy; and some late observers have not hesitated to assert that the inhabitants of these shells are either worms allied to the serpulæ, or rather, as Dujardin has proved in relation to many of them, not superior in organization to infusorial animalcules.*

of the cells or chambers, are not roundish and with an even edge, as those of the Orthoceros and Nautilus, but are slashed or jagged, into processes or appendages, which, laid together, tally and close into one another so strongly and curiously, that, when joined, the flats or surfaces of the whole Ammonis are embellished with a beautiful leaved work, exactly similar to that on the skulls of animals: and this by fossilologists is called the foliaceous sutures of the Ammonites."—Da Costa's *Elem.* 162.

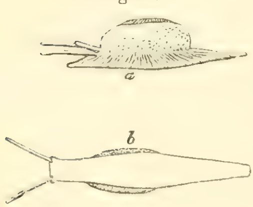
* Ann. des Sc. Nat. iv. 343. Dec. 1835.

The PTEROPODS have likewise no ordinal section; the members of the class, which is a small one, being distributed, in the manner of the Cephalopods, into certain genera; and the few established by other authors, on a more minute analysis of their forms, are reduced under these as of secondary importance. All the Pteropods are marine, floating at or near the surface, and having no power to creep along a solid base from their want of a foot. In consequence of their fragility and minor bulk they avoid the shore, and hold the high seas as a field for their possession. We have no British example of the class. The Clios and Limacines (Fig. 13) swarm in the Arctic Seas, where, though less than a common snail, they furnish an abundant food to the whale; the Cymbulies, so named from its canoe or slipper-like shape; the Pneumodermon, a name which signifies that the branchiæ are attached to the skin or surface; the Hyales, natives of the Mediterranean; the Cleodores, which belong to tropical seas,—these are the genera which Cuvier ranks under the class; and to them he is of opinion may be added a small fossil shell of a globular shape, and very thin texture, divided by a narrow transverse fissure somewhat widened in front. This was discovered by Defrance, and is named Pyrgo. Of all these it may be remarked that few, sometimes only one or two, species belong to each genus; and that the shell, which is sometimes wanting or entirely membranous, has a peculiarly transparent, brittle, and vitreous texture, with a certain degree of anomalousness in its form, which intimates that it belongs to an animal of abnormal character and habits.

Fig. 13.

The GASTEROPODS (Fig. 14) are a numerous class of mollusks, of whose character the slug and snail, familiar to every one, give a good idea. They are generally, like the latter, covered with a shell, but many are naked; and they inhabit, some the deep sea, the shore, the river, the lake, the marsh, and the shady groves as well as the parched sands. To fit them for such dissimilar localities, the Creator has varied the position and the structure of the respiratory

Fig. 14.

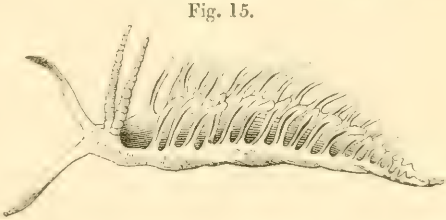


organs, and Cuvier has happily availed himself of this to divide the class into the following orders :—

1. Pulmones.—These breathe the atmosphere admitted into a pulmonary cavity by a lateral orifice, which the snail opens and shuts at pleasure; some of them have no shell, but the greater number are protected by one, which is often completely turbinate; the aperture, however, has never an operculum. They form two large families, the terrestrial (Pulmones terrestres), characterised by having almost all of them four tentacula; and the aquatic (P. aquatiques), which have only two tentacula. Of the former, the slug (Limax), and the snail (Helix), are the principal genera; the latter live in fresh waters, but incapable of extracting air from the medium in which they live, they are necessitated to rise frequently to the surface to obtain this. Our ditches contain them in profusion, where you may readily observe their motions, viz. the Planorbes, known by the shell formed, like the fossil Ammonites, of a tube wound up spirally on the same plane, but the cavity is, with a single exception, simple and continuous; while the shell of the Limneus is turbinated like the periwinkles.

2. Nudibranches.—These have no shell, and carry their branchiæ of various forms on some part of the back exposed to the direct influence of the circumfluent waters (Fig. 15). They are natives of the sea, and, from their figure, may be called sea-slugs. Cuvier has not separated them into families, but the principal genera are admirably described, for they were favourite objects of his study. The Doris has its branchiæ, sometimes feathered like an ostrich-plume, placed near the posterior extremity, and the creature has the power of concealing them when in danger. The Tritonia is more slug-like than the Doris, but its branchiæ form a curled fringe, interrupted at intervals, along each side of the back. The Thethys has, besides, a largely expanded veil over the mouth, imparting a very peculiar character to the genus. In the Glaucus the branchiæ are moulded into fingered fan-like fins; while in Eolides and Tergipes they form conical or cylindrical papillæ, disposed in series along the back and sides.

Fig. 15.



3. Inferobranches are similar to the preceding, but

the branchiæ are found partially concealed under the margin of their cloak, where they form a series of filaments nearly encircling the body. The order contains two genera only—the Phyllidia and Diphyllides—which are found in the Indian Sea and in the Mediterranean.

4. TECTIBRANCHES.—The branchiæ, in the shape of leaves more or less divided and non-symmetrical, are placed on the back or side, and are covered with a fold of the cloak, which almost always contains a shell more or less developed. In the character of the branchiæ they approach the Pectinibranches; but the Tectibranches, like the three first orders, are bisexous, although, in order to propagate the species, the animals require to act as if the sexes were distinct. The Aplysia, in which the branchiæ are dorsal and covered with a horny plate, may be considered as the typical genus of the order. In Pleurobranchus the branchiæ are unilateral. simpler, and more fully exposed. The Aceres have many characters which closely ally them to the Aplysiæ, but the shell is calcareous, frequently external, and always convolute; so that the pure Conchologist willingly allows them a prominent place in his cabinet under the name of Bullæ, while he disdains to notice their shelless confederates.

5. HETEROPODS.— These carry the branchiæ upon the posterior part of the back, where they form a row across it of little plumose tufts, and are, in some of them, protected, as well as a portion of the viscera, by a symmetrical shell. What best distinguishes the order is the compressed foot of its members fashioned into the form of a thin vertical fin, on the margin of which, under the head, we often perceive a small sucker—the sole vestige of the horizontal foot characteristic of the class. The Heteropods are eccentric in their appearance, natives of the Mediterranean and Indian Ocean, and frequently found floating with the Gulf-weed, on which they attach themselves by their sucker. The principal genera are the Carinaria, remarkable for its beautiful glossy navicular shell; the Atlanta, with a shell rolled up spirally, and in one of which Lamanon believed he had found the original of the Ammonites; and the Firola, which has no shell, but in whose singular shape fancy may trace a likeness to some ancient ship or New Holland war-canoe, the proboscis being raised and bent like the prow, while a thread-like filament, prolonged from the tail, simulates the oar that serves for its guidance.

6. PECTINIBRANCHES.—As the name implies, the branchiæ are pectinate, viz., composed of fringes arranged in parallelism like the teeth of a comb, and forming a leaf concealed

within a dorsal cavity which opens by a wide fissure above the head. The sexes are separate; and, with a very few exceptions, the species are covered with a turbinate shell, whose aperture the snail has the power of closing, when retracted, with a lid or operculum attached to the dorsal and posterior part of the foot. They constitute by far the most numerous division of Gasteropods, embracing probably not less than eight-tenths of all univalve shells, and you can at once form a general idea of the order by examining the periwinkle and whelk. In the former of these you will observe that the aperture is entire, that is, the lip is continuous all round the mouth without break or fissure, while the latter has a canal at its lower part prolonged into a sort of spout. Shells formed like the first constitute Cuvier's family Trochoides, including, among others, the genus Trochus, now partitioned into many subgenera characterised by having a conical spiral shell with a quadrangular mouth pearly in the throat; the Turbo, in which the shell is turbinate and the aperture round; the Paludina, which has a similar but unsilvered aperture, and is a native of fresh waters; the Littorinæ, like this in character, but an amphibious race, frequenting the sea-shores, and indifferent whether it is submerged or left dry by the recess of the tide; the Nerita, known by its semilunar mouth and its depressed spire; the Phasianella, one of the prettiest genera, speckled like the pheasant or guinea-hen; and the Ianthina, which is non-operculate, but provided instead with a cellular float to support it at the surface of the sea. The second family of the order is named Capuloides, in which the shell is oftenest simply conical like a limpet, but sometimes there is a small lateral spire, the interior exposed, however, by the disproportionably large aperture, which is entire and never protected with an operculum. The genera are few and sparing in species; nor is there any common example, excepting I can quote as such the shell called the Hungarian-bonnet by collectors,—the Capulus of science. The third family, or Buccinoides, may be represented by the whelk, but it includes, in its wide embrace, many shells which have no canal but where the lip of the mouth is merely interrupted by a sinus or emargination. Hence we find in it the beautiful Cones (Conus) and Cowries (Cypræa)—the glory of every rich collection, and whose deficiency declares the poverty of mine—the Ovulæ and the Volutes (Voluta), inferior to none in attraction and sportive variety. The whelk (Buccinum) gives its name to the family as being its typical genus; and it is followed by the turreted Cerithium, the spinous rock-shells (Murex),

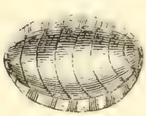
and the wide-cheeked Strombus, all of them being possessed by snails essentially alike in their anatomical structure and their leading habits.

7. Tubulibranches.—Similar in their organs of respiration to the Pectinibranches, from which Cuvier detaches them because of their being asexual or hermaphroditical,—a structure necessitated by their fixed condition; for, unlike all other Gasteropods, the shell of the Tubulibranches is immovably fixed to foreign bodies. This fixidity is accompanied with a considerable modification in the foot of the animal, which, its occupation gone, is reduced to a rudimentary state; and in the shell, which is spiral only at its apex, and ends in a long flexuous or straight tube, bearing a strong resemblance to the serpulous shell of some worms, with which, indeed, the Vermetus and Siliquaria, the principal genera of this order, have been often classified.

8. Scutibranches.—This comprises a small number of Gasteropods likewise very similar to the Pectinibranches in the form and position of the branchiæ as well as in the general form of the body; but, like the last, they are hermaphrodites, and, unlike them, have the power of walking to and fro. Their shells are widely open, ear-shaped or patelloid, non-operculate, so that they cover the animal like a buckler or dish rather than contain it. In their interior anatomy they make an approximation to the bivalvular mollusca, and their shell has a certain resemblance to a single valve of that class. The Halyotis, or ear-shell, the Fissurella, and Emarginula, separated from the Patella of Linnæus, are the principal examples.

9. Cyclobranches.—Another small hermaphroditical family distinguished by their branchiæ, which, in place of being situated within a peculiar cavity, form a filamentous ribbon between the margin of the cloak and foot, nearly encircling the body. The genera are Patella and Chiton (Fig. 16), exceedingly dissimilar in their external appearance,—the former being covered with a simple conical shell, the latter with a series of testaceous plates arranged along and across the back.

Fig. 16.



The fourth class of mollusca—the Acephales—are all aquatic animals and very numerous. The first order in it, named A. Testaces, have the respiratory organs in the form of four broad leaves, a pair on each side of the body, which again is always contained within a bivalvular shell, that, in a few instances, has some additional pieces affixed over the hinge. The cockle, the mussel, and the oyster, are members

of the order, and make its leading characters at once familiar to you. The structure of the shell and of its hinge, and the habits of the animals, will be afterwards detailed; all I have at present to do is to indicate the names of the great families among them. First on the roll we find the Ostraces or oysters, whose mantle is entirely open in all its circumference, and the valves of the shell are closed by a single central muscle. The edible oyster is the true representative of the family, but Cuvier includes in it also the Pectens, the Anomiæ, the Spondyli, the Malleus or hammer-shell, the Avicula or pearl-oyster, the silk-spinning Pinna, the Arca, and a considerable number of fossil genera allied to one or other of those just mentioned. The second family is the Mytilacés or mussel-tribe, in which the mantle is open in front, but with a distinct aperture for the excrementitial discharges, and there are two adductor muscles to close the shell; one of them, however, is very small in some of the genera, and placed near the hinge. The family embraces the sea-mussels as well as those of our rivers and ponds, and some (Lithodomus, Coralliophages,) which have the faculty of boring into solid substances. The Camacées have the mantle close, perforated with three apertures; through one the foot is protruded, the next serves for the ingress and egress of the water necessary to respiration, and the third for the discharge of the excrements. The gigantic Chama is the best known of the family, which is a small one. It conducts us to the Cardiaces, so called from the resemblance of the shell to a heart; they have two adductor muscles, a mantle open in front, and furnished besides with two separate tubular apertures at one extremity. The cockle (Cardium) is of this family, which is widely spread and abundant in variety, for the genera Donax, Cyclas—inhabitants of fresh waters—Tellina, Venus, and Mactra, the most numerous in species of all bivalves, with all the kinds allied to these, are reputed to belong to it. The fifth family is named Enfermés, because the mantle is open only at the anterior end or near the middle for the passage of the foot; and at the other end there are two tubes, often bound in one common envelope, and capable of being extended to a considerable length. The shell gapes more or less; that is, the animal cannot by any effort so aptly close the valves, but that an open space, generally at each extremity, remains. The Enfermés burrow in the sand to considerable depths, where you may dig up at low tides the Myæ and the Solens, or razor-shells, the best specimens of their family. Cuvier, however, places in it also the Pholas, and the "fell Teredo" of which

I have had occasion to write so much, and which bore some in wood and some in rock, as you are well aware. At the end of the family we find a doubtful station assigned to the Aspergillum (Fig. 17), or water-pot shell, of which a perfect specimen will be a very desirable addition to your collection.

Fig. 17.

The Acephales sans Coquilles, the second order of the class, are so dissimilar to the first, that Cuvier says it might be raised to the rank of a distinct class, if such were thought convenient. Their branchiæ assume diverse forms, but are in no instance divided into four leaves or lamellæ; on the contrary, they usually form a regular net-work on the inner surface of the tunic. Shell they have none, and consequently the conchologist disallows their claims upon his attention, but there is no order more interesting to the physiologist. The covering which stands in lieu of a shell is a coriaceous, or cartilaginous, or, sometimes, a merely fleshy coat, with two circular apertures on some part of it; one for the admission of the water containing all the necessary food and air, the other for the discharge of their excretions. There are two families. The first comprises the genera, of which the individuals are isolated and complete in themselves, though sometimes occurring in clustered groups; the second, those which are compound beings, a certain number of individuals being organically associated to constitute one body. The Salpæ—singular gelatinous animals which float in the sea in long ribbon-like chains or with every link detached,—belong to the first, where likewise are located the Ascidies, very unlike the former in all things, in the form and structure of the cloak, in the disposition of the branchiæ, and in their permanent fixidity to rocks, shells, or other foreign bodies. The compound family (les Aggrégés) is a very remarkable one, connecting the molluscans with the zoophytes, among which they were arranged, until the laborious researches of Savigny proved the fallacy of their position: it contains locomotive genera, such as Pyrosoma, one of the most wonderful of created beings; and genera permanently fixed, such as Polyclinum, with its animalcules disposed in star-like figures shining through a pellucid jelly.

The Brachiopods have considerable affinity to the bi-

valve mollusca. Like them, they are enclosed in a bivalve shell; but this is always fixed or cemented for life to one spot. They were crowded beyond calculation in former seas before the present race of marine mollusca had existence, but few have survived the cataclysm, and, from their present rarity, they are highly prized by collectors. Cuvier reduces them all to three genera; the Lingula, a sort of small mussel hanging from rocks in deep water by a cylindrical fleshy pedicle; the Terebratula, something like a Pecten or Cockle, with the under valve perforated to give passage to the pedicle by which the shell is attached; and the Orbicula, known by its circular figure and the inequality of the valves, the upper being elevated into a shallow cone, while the lower is flat and cemented to the rocks.

This letter, however dry and tedious in its details, will require more than one perusal to fix the names of the principal tribes on your memory; for unless these are familiar as household words our progress must be halting:

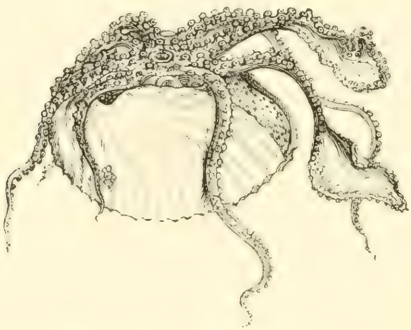
> "—— *names* are good; for how, without their aid,
> Is knowledge gained by man, to man conveyed?"

LETTER VIII.

ON THE LOCOMOTION OF THE MOLLUSCA.

The great importance which, in the preceding arrangement, is attached to the locomotive organs, naturally draws our attention to these in the first place; and we shall find that their various modifications have induced a corresponding variety in the mode in which this class of beings move themselves. Hence, by throwing a cursory glance among them,

Fig. 18.



we might indulge ourselves with what some naturalists delight in—a scene rising by a gradual concatenated series from the half zoophytical mollusk, whose fixidity is permanent as the rock on which it is placed, to the fish-like Cephalopod wandering at freedom through the ocean; passing from the oyster to the Ligula waving to and fro on a flexile stalk, thence to the burrowing bivalves, which gradually lessen in dependency on their furrows and mingle with their halting congeners; among whose tribes, again, there are some that—floating on the surface—lead us to the Gasteropods, which, through many a linked transition, pass insensibly to the winged natatory Pteropods. There are, in this hasty sketch, many chasms which a little ingenuity might fill up with osculant groups, and connect the horrid gaps which the naturalists alluded to seem to abhor as much as Nature herself is said to abhor a vacuum; but the scene would then be

in truth after the fashion of the maker's mind, and little in accordance with what a sober survey of the reality discloses. This is not less beautiful nor less designed, but so far from rising on the spectator, like alpine scenery, the more perfect as he ascends, it lies wide before him with all its variety level to his gaze, and perplexing by its unpatterned intricacy. In every, or nearly in every, class or order, there are some families which swim whithersoever it listeth them, some which crawl or trail themselves along the solid ground, some which burrow and which confine themselves to their narrow cells; and others there are which have no power of changing their sites, but live and die on their natal spot. Instead therefore of making each class pass in separate review before you, exhibiting, in a coloured glass, their progressive rise in motive capabilities, I rather choose to leave system for the present; and, grouping, somewhat loosely, the molluscans into the swimmers, the crawlers, the burrowers, and the sedentaries, I will lay my illustrations before you under these several heads.

Before entering on the details, however, I must remind you of the close connection between the shell and its inmate, by which the former, instead of being a drag and hinderance, becomes essential to the movements of the latter. The connection between them is inseparable during life, and is effected by the medium of muscles which go from the animal to be inserted to the parietes of its dwelling. The mollusca with bivalved shells are in this manner attached by one or two large and powerful muscles, called sometimes transverse, because, passing through the body, they are inserted into both valves at opposite points; and sometimes adductors, because their office is to close the valves and keep them so in opposition to the elasticity of the ligament at the hinge which tends to separate them; and the astonishing force with which they act is well illustrated by the extreme difficulty of opening those of an oyster. In the mollusca which are covered with a shell in form of a case or sheath, as in some Pteropods and Gasteropods, the animal is connected to the base of the shell by a large dorsal retractor muscle. In simple conical univalves, as the Limpet (Patella, Linn.), the body "is fastened to the circumference of the shell by a ring of fibres, which are attached all round the shell, and which, after piercing the outward covering or cloak, are inserted in the edges of the foot, and interlaced with its circular fibres. Anteriorly they leave a free space for the passage of the head. This muscle, by its contractions, brings the foot and the shell closer together, and compresses the body; on relaxing,

it allows the shell to be raised up by the elasticity of the body." The snails of spiral shells are bound to them by two muscles, which arise from the pillar, and, having penetrated the body below its spiral part, run forward under the stomach, and spread their fibres in several slips, which interlace with those of the muscles proper to the foot, the substance of which they enter. It is obvious from this direction, that, on their contraction, the body of the snail must be drawn within the shell. When it wishes to reissue, the head and foot are forced out by circular fibres, which surround the body immediately above the foot.* The muscles, like the muscles of superior animals, are composed of parallel fibres, but of a bluish-white colour,† soft and jelly-like, and rather loosely connected; for the cellular substance, which binds together those of red-blooded animals, is here very generally wanting. They have, apparently, no tendons; but this is, according to Cuvier, owing to the colour being the same in the tendinous and the fleshy parts. The fibres are, in general, closely and inextricably interlaced, the insertions being lost in one another, or in the skin under which they lie, and from which, indeed, it seems impossible to separate them by any definite line. Chemically they consist of fibrine, but the medium which cements them to the shell appears to be gelatinous, for it is loosened and detached by maceration in spirits of wine and boiling, operations which have an opposite effect on fibrine.‡

I. Swimmers. — The Pteropods are the most entirely natatory of all the mollusca. Created to occupy the high seas, they are organized in evident aptitude to the place assigned them, with a light shell, which affects not their buoyancy, and with fins for progressive motion. They are found far at sea, in large herds, swimming about in a lively manner, by undulatory or flapping movements of their membranous fins, which open and close like those of the butterfly while basking in the sun. They shun the light-

* Cuvier, Comp. Anatomy.

† Bohadtch says, that some of the muscular fibres of the Aplysia are red. —*De Anim. Mar.* 12.

‡ "The muscles of mollusks either form a flat disk, or are distributed in the skin so as to dilate and contract it, or are arranged about the mouth and tentacles, which they put in motion. However varied the disposition of the muscles may be they always form very considerable masses, in proportion to the size of the animal, and have a soft and mucous appearance, such as is not seen in the contractile fibres of the other departments of the Animal Kingdom. This peculiar aspect no doubt arises from the numerous small cavities found in the muscles, and the mucous glands which are distributed through them."—Agassiz and Gould's *Princ. Zoology*, i. 52.

some day, and sink, as the sun rises, into the bosom of the deep, to attain that shaded gloom which suits them; but on the evening's approach they gradually again ascend to the surface, and regain all their vivacity,—so that if some will fancifully seek amongst them the molluscan analogues of insect-butterflies in their manner of natation, they will not fail to mark the correspondency between them and the moths in their crepuscular and nocturnal habits. The little Hyales (Fig. 19) first appear. About five in the afternoon, when the garish eye of day begins to grow dim, two or three species venture upwards to the field of their occupancy; as evening advances several small species of Cleodores rise in great number with other Hyales and Atlantes, but the larger kinds do not leave the abyss and mingle in the crowd until night lends them her friendly veil; and some species, as the Hyalæa balantium, are even so fearful of the light's malign influence that they do not come to the surface excepting when the night is very dark. After a few hours' disport, the lesser species begin to descend and disappear; the larger follow at a little later hour, so that towards midnight only a few wandering individuals can be taken. These may possibly remain even to the dawn, but the sun's rise is the signal which recals them to their home. After this not a single Pteropod is to be seen either at the surface or at any depth to which the eye can penetrate. Each species has its own time at which it rises up and goeth down, determined not by the clock, as you will readily believe, but by the degree of obscurity in the heavens, so that in an overshadowed day they rise earlier than in a cloudless one, and sink earlier also to repose. From these habits M. d'Orbigny infers that each species dwells habitually in the water at a depth peculiar to itself, and where it can enjoy the shade of obscurity suited to its disposition, the light being of course tempered in exact proportion to the thickness of the layer or bed of water it has had to pass through. The species then comes to the surface only at that time of day when the dusk is nearly the same as that which reigns in the zone occupied by the creature in the bosom of the deep. As the sun rises, the Pteropod sinks lower until it has reached its maximum of descent; but when the sun has passed the meridian, the snail's upward course begins, and with a gradual ascent, regulated by the sun's decline, he passes up and up, until

Fig. 19.

the surface is reached. Light, therefore, and not the search after food, or the desire of breathing a freer atmosphere, as Rang believes, is, according to D'Orbigny, the true regulator of their diurnal movements. It is not a sufficient objection to this theory to remind me that the Pteropods are eyeless and blind, for numerous facts prove that many animals which have no organs of vision are still powerfully affected by the light, seeking or shunning it as their sensations teach them to find pleasure or pain under its influence.* But still we may ask, why do the Pteropods disappear, as the darkness thickens, to a retreat certainly still darker, and why are they not ready to greet the dawn in its approach as well as the evening fall, seeing that there must be, in both, periods at which the shade of light will be of equal intensity? Let it also be remarked, that their congregations on the surface are variable and inconstant. For some successive nights a species will throng the naturalist's fatal net, when, without any visible cause, it may be cast and drawn for two or three nights in succession and in vain — not a single individual has left his subaqueous haunt, — after which they will again suddenly rise as numerous as before. It is neither an instinctive prescience of a storm, nor a storm itself, which hinders them, for D'Orbigny often took them during stormy nights in abundance; and the belief that at such seasons they lay sunk in the abyss seems to have originated in its seeming reasonableness to the naturalist, who deemed it consequently fruitless to endeavour the capture of such fragile creatures among the billows of a troubled sea.

By what mechanism the Pteropods balance themselves in the deep and vary their position, is, perhaps, scarcely determined. Cuvier conjectures, with reference to the Clio, that there may be a collection of fluid or air in a space between the sac and the viscera, by compressing which the animal will sink; and it will rise when the air or fluid is allowed to distend the relaxed sac to its full capacity.† D'Orbigny seems to think that nothing is required beyond their muscular efforts and the movements of their fins, and though this explanation would seem to require a continuance of action, to which there is no relaxation or end, it is better to acquiesce in it than to call imaginary structures to our aid. The Pteropods, says D'Orbigny, have a peculiar mode of swimming in subservience to their form: the cephalic fins can propel the animal forwards, or sustain it afloat, only by

* The Clio, it is now ascertained, has two eyes, apparently of a very complete character.—See Jones's *Animal Kingdom*, p. 428.

† Mém. sur les Mollusq. ii. 6.

ceaseless movements similar to those of the wings of the butterfly. These fins are rowed with remarkable ease and quickness, and according to the direction of the motion, the creatures advance horizontally, rise or descend, while the shell is kept in a vertical position or slightly inclined. At times the Pteropod will turn itself without altering its place, or poise itself still and motionless at the same depth; but this immobility is to be observed only in a few species, while all make habitually the papilionaceous movements. If, during their course, any strange body comes in contact with them, or a sudden shock agitates the vessel in which they are kept, they fearfully fold their fins upon themselves, or, in some species, withdraw them in the shell, and allow the body to fall to the bottom of the vessel. It is probable that on a similar alarm in a state of liberty, they would unfold anew their fins, and stop their downward fall, when the body had sunk to a depth which placed it beyond the reach of danger. Rang has asserted that some of the Creseis* do occasionally cluster on the gulf-weed, where they rest themselves by embracing the leaves and stalks with their fins, but D'Orbigny has never been witness of such an occurrence, which is probably accidental, for the species of Pteropods of which it is related become, he says, rare in the gulf-weed fields; and as the fins are not calculated for prehension, they might too easily be driven amid the crowded weeds where their thin brittle shells could hardly resist the shocks to which they would be exposed.†

The Pteropods are most numerous, both in species and individuals, under the torrid zone, but a few "swarm populous" in the arctic seas, whose prolific waters are in strong contrast with the sterility of their shores and barren lands. The Clio borealis, in especial, fills them in some seasons with such teemful fecundity, that the whale cannot open his mouth without necessarily engulphing myriads of them. The Limacina, (Fig. 13) is not less profuse in the same seas, of whose habits the worthy Otho Fabricius has given a lively account, which loses, however, much of its spirit in my translation. "The shell is its boat, which the snail rows admirably through the water by the regularly-timed strokes of the raised fins. In this act the open extremity of the shell is the prow, the opposite end occupies the place of a poop, and the margin of the body-whorl resembles and performs the office of the keel. I have often seen it with admiration and pleasure,—"quod sæpius

* Manual, 21.

† Ann. des. Sc. Nat. Zoologie, n. s. iv. 189—192.

mirans delectansque adspexi." It can move in a retrograde manner. When weary with rowing, or when touched, the little boatman contracts its oary fins, and drawing itself within the shell, sinks to the bottom, where it rests a short space either upon the keel, or the prow, or the vertex, but never on the umbilicus. Then again it rises upwards, rowing obliquely until the surface has been gained, where its course is held in a straight line* o'er the trackless surge."

The small Gasteropod order which Cuvier has called Heteropods, are fully as pelagic as the Pteropods, and, like them, have no other way of changing their place than by natation. The foot, instead of forming a flat horizontal sole, you will remember, has a vertical direction, and assumes the figure of a compressed semicircular fin, which being moved by its own muscles from right to left, propels the animal forwards,—like a sculler who works his boat with a single oar. The fin is ventral, but, on a hasty glance, you might mistake it for a dorsal crest; for the Heteropods—as indeed all pelagian mollusca do—swim in a reversed posture, the foot to the surface and the back looking downwards. In the Carinaria—beautiful creatures! clear as crystal and painted with the liveliest colours,—and in the Firola, this ventral fin is aided in its office by some subsidiary membranes situated upon the neck or near the tail, but whose powers of propulsion are inferior to its own. Combined, however, they give to these genera a velocity superior to what has been noticed in any other tribes of mollusks; being, indeed, very remarkable for the quickness of their movements, propelling themselves in a forward or a backward course, in a straight or a curved line, with equal facility, and without any retardation of their pace. The Atlantes, which are destitute of these secondary fins, and whose body, compressed in the small space of their spiral shell, presents less resistance to the circumfluent medium, are slower of foot; and instead of moving in an even line, they advance after the manner of the Hyales, with alternate periods of activity and rest.

For the Pteropods, as we have seen, there is no organ of rest; they float or swim unfixedly in the abyss of waters, realising in their persons the fable of the paradise-birds, which ever hovered in the heavens, too aerial and spiritual to require the support of our gross earth; but the Heteropods need occasional repose and a cessation from activity,—and how admirably is the foreseen want provided against! Where are they to rest—where fix their anchor in the world

* Fauna Groenlandica, 388.

of unstable water around them? They are created to live, and are born amidst the fields of sea-weed, which voyagers describe with amazement, as covering leagues of sea within the Tropics; and to enable them to attach themselves to the narrow leaves of the sargassum, they are furnished by their Creator with a small sucker, which, like a cupping-glass applied against the surface of the leaf, suspends them there without exertion. If such wonderful adaptations—such alliances between things which seem most remote—such design in such apparent chance, do not warm you with a conviction of the presence of an Omniscience, whose eye is over all his works, you are made of an earthier soul than I am well persuaded you are, and are most unfit for a naturalist. The little sucking pouch is situated on the superior and posterior margin of the ventral fin, and is formed by a kind of duplicature of the membrane which covers that organ.*

The presence of a sucker in these molluscans reminds me of the cotyligerous Cephalopods, of which it has been asserted that the species, having two long arms in addition to the shorter feet (Decapods), anchor themselves to the submarine rocks when they cannot otherwise withstand the agitation of a stormy sea;† although, in general, the suckers are rather to them organs of prehension to arrest their prey than organs of rest. All the Cephalopods are good swimmers; but, in their mode of natation, they are as peculiar as they are in appearance and character, for their movements are retrograde, while the head is directed downwards and backwards, and the body held nearly in a perpendicular position. The majority of the Decapods have a muscular fin on each side, by whose aid they accomplish their movements in this apparently inconvenient posture, moving with great vivacity by sudden and irregular jerks. Pliny says, that the Loligines can fly,‡ and the term is in truth as applicable to

* Rang. Man. pp. 26—28, and 120.

† Rondel. Hist. des Poiss. i. 366.

‡ Holland's Pliny, i. 250. Dr. Gould says of Loligo illecebrosa,—"So swift and straight is their progress that they look like arrows shooting through the water."—*Invert. Massachus.* 318.

"The action of the powerful muscles in the terminal fins of the Calamaries must be aided in its effect upon the body by the elasticity of the internal pen or gladius. By these means they are enabled not only to propel themselves forward in the sea, but they can strike the surface of the water with such force as to raise themselves above it, and dart like the flying-fish for a short distance through the air. This is the highest act of locomotion, the nearest approach to flight, which any of the molluscous animals have presented."—OWEN's *Lect. Invert. Anim.* 348.

them as it is to the flying-fish,—being, by the vigour of their strokes, sometimes raised some feet above the level of the water. Thus Colonel Sykes mentions, that several specimens of Loligo sagittata leaped on board the vessel in which he was returning from India, while the wind was light and the sea calm.* In some species their motions are greatly assisted by the broad membranes that fringe the feet and connect them together at their base. Such membranes are found on the two inferior pairs of feet in the Loligopsis veranii,—a species to which I shall call your attention more particularly hereafter. The Sepiæ aid and regulate their motions by the power they have of introducing air at option into the numerous cells of the backbone, and thus at will varying their proportionable weight to the sea in which they live.† In the finless Octopods the feet, which are all winged with a membrane, become the sole organs of natation; for though Lamarck has chosen to maintain that this family can only trail themselves along the bottom of the shore they inhabit by means of their arms,‡ we know very well that they are excellent swimmers,§ propelling themselves by repeated strokes of their members, used much in the fashion that a frog uses its legs. Thus Professor Grant, when describing the Octopus ventricosus, says,—"The animal swam several times hurriedly across the basin, always with its posterior extremity forward, by repeatedly striking forward the whole of its webbed arms at the same instant."|| Mr. Cranch likewise informs us, that the finless Ocythoes swim freely when out of their shell; having, as he adds, all the actions of the common Octopus of our seas. The Octopods, however, do walk with equal ease, dragging their body, which is round and proportionably small, along the ground at the rate, it has been ascertained, of not less than seven feet in a minute. Should they wish to accelerate their pace, they inflate their body until it resembles a distended bladder; when, leaving go all hold and casting themselves forward, they roll over and over with great velocity, and often effect an escape which would otherwise have been impossible.¶

* Proc. Zool. Soc. 1833, pt. i. p. 90.

† Good's Study of Medicine, iv. 424.

‡ Anim. s. Vert. vii. 583, 656.

§ Cuvier, Mém. i. 3.

|| Edinb. Phil. Journal, xvi. 313. See also Darwin's Journal, iii. 6. Yet Mr. Couch says of Octopus vulgaris, "It is scarcely capable of swimming; but it is a common amusement of boys to cause it to climb up the ascent of a pole or mast."—*Cornish Fauna*, 82.

¶ Blainville Man. de Malacologie, 149. The Naturalist, i. 190.

The testaceous Cephalopods, of which I have already told you there are only a few living representatives, appear to reside habitually at great depths in the ocean, whence they have the capability of ascending from time to time to the surface; yet their navigation there, so far from being a natural portraiture of a ship driven with sails and oars, is in all probability of a passive kind, or influenced only by the reaction of the respiratory currents when expelled by the funnel upon the surrounding medium. The specimen of Nautilus pompilius, brought home to this country by Mr. Bennet, and which has afforded Mr. Owen the means of preparing one of the best and most beautiful monographs in comparative anatomy, was taken on the coast of the New Hebrides floating on the surface, but just in the act of again sinking to the bottom,*—where lies its proper scene of action, for the chief locomotive organ is a flattened muscular disk that surmounts the head, analogous to the plane foot of the Gasteropods, which the Nautilus must also resemble in its manner of creeping. The description of Rumphius is very graphic. "When he thus floats on the water he puts out his head and all his barbs (tentacles), and spreads them upon the water, with the poop (of the shell) above water; but at the bottom he creeps in the reverse position, with his boat above him, and with his head and barbs upon the ground, making a tolerably quick progress. He keeps himself chiefly upon the ground, creeping sometimes also into the nets of the fishermen; but after a storm, as the weather becomes calm, they are seen in troops floating on the water, being driven up by the agitation of the waves. Whence one may infer, that they congregate in troops at the bottom. This sailing, however, is not of long continuance; for having taken in all their tentacles they upset their boat, and so return to the bottom."†—By what mechanism the Nautilus effects his ascent and descent is still conjectural. Dr. Hook supposed that it had the power of generating air into, and expelling it from, the deserted chambers, thus regulating its specific gravity in the same manner as fish by means of their air-bladders. Mr. Parkinson, in adopting this theory, assumes that the seat of the accumulation of the gaseous fluid is the membranous tube which runs through the siphuncular apertures of the septa and traverses all the chambers; and he believes that this tube has a corresponding power of dila-

* Mr. Bennet says that the Nautilus, when at rest, either afloat or on the ground, covers its shell with the mantle, which is like that of the Cypræa. —*New South Wales*, ii. 409.

† Owen's Memoir, 53.

tation and contraction.* If we adopt this theory, we may suppose that the contained air is a secretion of the artery which is continued down the membranous tube, as proved by Mr. Owen's dissections; and it may afterwards escape by a communication which exists between the tube and branchial cavity through the medium of the pericardium. "But," says Professor Owen, "it must be admitted, on the other hand, that the size of the artery seems barely adequate to support the vitality of the membrane, much less to effect a secretion, for which in fish (at least, such as have an outlet to their air-bladders), an ample gland appears to be indispensable; and with respect to the outlet, the oblique and contracted nature of the passage is ill calculated to allow of an escape of the gas sufficiently rapid to answer as a self-preserving action, or a means of defence against sudden assaults."† These objections, fatal perhaps to Parkinson's views, Dr. Buckland attempted to obviate by a modification of Hooke's theory. Assuming that the chambers are air-receptacles, the Doctor conjectured that when the animal is at the surface and wishes to sink, it forces into the siphuncle a quantity of water previously contained in the pericardium or bag enclosing the heart. The consequent distention of the siphuncle compresses the air in the chambers, and the bulk of the exterior of the body being thereby diminished, its specific gravity is increased and it sinks. When it wishes to rise it has only to withdraw the pressure from the pericardium; the elasticity of the air in the chambers forces the water back from the siphuncle into the external cavity, and thus by increasing its total bulk renders the specific gravity again less than that of the water. The main objection to this hypothesis is derived from the structure of the syphonal tube, which seems to be little capable of dilatation in any species of Nautilus, or many-chambered mollusk; and, in some species, is so coated over with a calcareous incrustation as to render much swelling of it altogether impossible. Perhaps, as Professor Owen states, nothing more is necessary to enable the Nautilus to rise than the full unfolding of its organs and their protrusion from the shell. Buoyed by the expanded organs, the animal has only to yield itself to the upward force derived from the shell being specifically lighter than the medium which surrounds it, for we assume that the chambers of the shell are filled successively with a light gas in the course of their formation. After his notice of the structure of the

* Outlines of Oryctology, 167. † Owen's Memoir, 46, 47.

syphon Professor Owen continues:—"From these facts I incline rather to the conclusion, that the sole function of the air-chambers is that of the balloon; and that the power which the animal enjoys of altering at will its specific gravity must be analogous to that possessed by the freshwater testaceous Gasteropods, and that it depends chiefly upon changes in the extent of the surface which the soft parts expose to the water according as they may be expanded to the utmost, and spread abroad beyond the aperture of the shell, or be contracted into a dense mass within its cavity. The Nautilus may likewise possess the additional advantage of producing a slight vacuum in the posterior parts of the chamber of occupation, which is shut out by the horny cincture and muscles of adhesion from the rest of that cavity."*

It is scarcely a digression to introduce here some account of the Paper-Nautilus or Argonauta argo, Linn. (Fig. 18), with the history of which you must, to a certain extent, be familiar, since it has been admitted into every work treating of the Wonders of creation, and some of our popular poets have happily availed themselves of it. It is the "little Nautilus" of Pope, who, with a certain class of metaphysical inquirers, regards it as the source whence man has derived his first notions of ship-building; it is "the Ocean Mab, the fairy of the sea," of Byron; but, of all our poets, Montgomery has the most beautifully described it:—

> "Light as a flake of foam upon the wind,
> Keel upward from the deep emerged a shell,
> Shaped like the moon ere half her horn is fill'd;
> Fraught with young life, it righted as it rose,
> And moved at will along the yielding water.
> The native pilot of this little bark
> Put out a tier of oars on either side,
> Spread to the wafting breeze a twofold sail,
> And mounted up and glided down the billow
> In happy freedom, pleased to feel the air,
> And wander in the luxury of light."

This description, although poetical, is in perfect accordance with that which has been handed down to us from a very early period. "But among the greatest wonders of nature," says Pliny, "is that fish which of some is called Nautilos, of others Pompilos. This fish, for to come aloft

* Lect. on the Invert. Anim. 330. M. Vrolik has proved that the chambers of the shell contain only gas with a greater proportion of azote than the atmospheric air, but no carbonic acid.—*Ann. and Mag. N. Hist.* xii. 174.

above the water, turns upon his back, and raiseth or heaveth himself up by little and little: and to the end he might swim with more ease, as disburdened of a sinke, he dischargeth all the water within him at a pipe. After this, turning up his two foremost claws or armes, he displaiceth and stretcheth out betweene them a membrane or skin of a wonderful thinnesse: this serveth him in stead of a saile in the aire above water: with the rest of his arms or claws he roweth and laboreth under water, and with his taile in the mids, he directs his course, and steereth as it were with an helme. Thus holds he on and maketh way in the sea, with a faire shew of a foist or gally under saile. Now, if he be afraid of anything in the way, he makes no more ado but drawes in water to ballace his body, and so plungeth himselfe down, and sinketh to the bottom." *

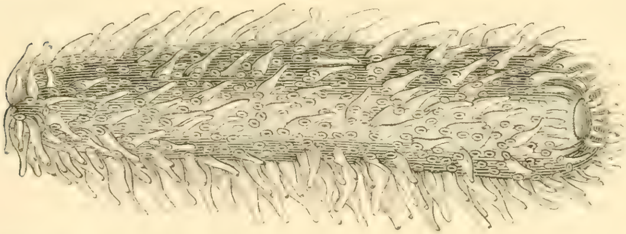
This picturesque description is, I regret to tell you, in a great measure, imaginary. The verisimilitude of the Argonaut to the sail-governed ship was first lessened by Rumphius, who may have been a witness of its proceedings; † but the shock which his testimony gave to the history, and the metaphysician's dream, might have been counterpoised by that of Bosc,‡ had not the whole account of this latter naturalist been so obviously erroneous, although said to have been made from personal observation. But recent discovery has greatly reduced its marvelousness. The Argonaut, when submerged, crawls along the bottom, like other cuttles, by the aid and contortions of its simple arms, holding the shell, back upwards, in the grasp of its two velated arms, which are retroverted for this purpose, and closely applied along the keels, the extremities being at the same time so dilated and spread out as to embrace and conceal the shell entirely.§ "During calm weather," says Madame Jeannette Power, "and in quiet water, if not feeling themselves observed, they make a parade of their many beauties, rowing with full sails, tinged with beautiful colours, and resting the extremities of the sail-arms on the two sides of the shell, or embracing the shell with them. It is then that their different movements and habits may be observed; but I was obliged to act with the greatest caution in order to enjoy this spectacle, for the creatures are extremely suspicious, and no sooner find themselves observed, than they let themselves fall to the bottom of the

* Holland's Plinie, i. 250. † Griffith's Cuvier, xxxix. 300.
‡ Hist. des Coquil. iii. 255.
§ Jones's Anim. Kingd. 444, fig. 207.

cage, and do not rise again for many hours."* By what process the animal rises to the surface I have not seen distinctly stated anywhere; but on the surface it certainly neither sails nor rows, "but its arms quit the shell still less than in creeping, because, being turned upside down, it would the more easily be separated from it; and thus locomotion takes place, as in the other animals of this class, by the alternate dilatation and contraction of the mantle or covering, drawing in and throwing out the water in which the animal is immersed: it then swims backwards, like the cuttlefish and calamaries."†

Among the Mollusca tunicata there are several which, though they more properly float than swim, may be conveniently noticed here. The Salpæ or Biphores, as the French usually call them, abounding in the seas of warm climates, translucid as their native waters, and often united in chains, after a pattern peculiar to each species, are driven along the surface with considerable quickness by alternate contractions and expansions, and by the propulsion they receive from a current of water, which is made continually to traverse the long diameter of the body, sucked in by the posterior aperture and issuing in a stream through that on the side of the mouth. Hence the body is always pushed backwards — a circumstance that has misled some

Fig. 20.



naturalists to describe the posterior aperture for the true mouth.‡ The Pyrosomæ (Fig. 20) are a still more singular family of the same order. Each seeming individual of this

* Charlesw. Mag. N. Hist. iii. 106. † Sander-Rang in *ib.* i. 401.

‡ "These long chains swim through the tranquil water with regular serpentine movements, for the creatures of which they are composed contract and expand simultaneously, keeping time, as it were, like a regiment of soldiers upon parade. Each chain seems consequently to be a single being, acting through the influence of an unique will; thence sailors often look upon it as a reptile, and in many seas the salpa-chains are called sea-serpents."—Forbes and Hanley, *Brit. Mollusca*, i. 48.

genus is, in fact, a numerous colony of little mollusca, every one in its own cell, distinct, yet inseparably connected with its fellows. Collected into the figure of a gelatinous cylinder, open at one extremity and closed at the other, and roughened externally by a multitude of tubercles disposed sometimes in rings and sometimes irregularly, they float in the Australian seas like stars of this lower world, shedding around them a halo of light, brilliant indeed, but surpassed in beauty by those other colours of the creatures which it serves to disclose; colours which come and go at pleasure, glorying, as it were, in their subtle changes, passing rapidly from a lively red to aurora, to orange, to green, and to azure blue; a magic scene, compelling more than the admiration of every beholder.

II. Crawlers.—I have already mentioned that the octopod cuttles drag themselves along the ground with a speed for which they seem ill adapted: —"It is a difficult task," says the Rev. Mr. Guilding, "to secure them without a spear, so quickly do they hobble away under the rocks;" * and you have just read, that the shelled Cephalopods are normally creepers. The other molluscans of this division belong to the classes of Gasteropods and bivalved Acephala; but there is a very considerable difference between them in the mode of their progression. The Gasteropods move forwards with an even, gliding motion and continuously; the Bivalves drag themselves along, halting at every step; and those with a compressed elbowed foot, making often and short leaps. The difference is determined by the structure of the foot. In the Gasteropods this forms a flat, oblong, or linear-oblong sole, constituting the inferior plane of the body, and composed of muscular fibres, which have a longitudinal direction down the middle, where they are collected into two bands, while the fibres on each side are mostly transverse. The figure of the foot in Bivalves has been compared to that of the tongue of a quadruped, and the comparison is equally illustrative of its structure, which is a close tissue of interwoven muscular fibres: the organ is free, projecting like an arm from near the centre of the body, and is

* Mag. Nat. Hist. ix. 194. Blainville shortly and graphically describes the motions of the Octopods on land: "Being thrown, with a number of other live creatures, upon the bridge, they moved very nimbly in all directions, a little after the manner of crabs, at the same time elevating their backs, so that the tube might not touch the ground; that is to say, raising the point of junction of the head and trunk, crawling backwards upon the lower surface of the mantle or sack, and forwards with the help of the four arms on each side, the upper ones before, and the lower ones behind, a little like the Ophiuræ."—Charlesw. *Mag. N. Hist.* i. 400.

incapable of being applied in a horizontal position to a flat surface.

The Gasteropods crawl along at a pace proverbially slow, —"slow crawls the snail,"—but there are degrees of sluggishness among them, and it may be regarded as generally holding true, that the narrower and more elongated the foot, the quicker the motion, which becomes retarded just as the organ tends more to the oval or round. Thus the snail greatly excels in his paces the shield-like limpet, and the slug beats the Doris. A foot either disproportionably large or small is also a hinderance to progression. The Cyprææ and the Olivæ have a foot considerably larger than the shell, with a deep furrow run down its centre, and these are sluggish genera. The Yet of Adanson (Cymba neptuni) has what we would call a monstrous foot, being as broad again as the shell and one half longer when expanded; nor can it be withdrawn within the shell by any effort of the animal. We may conclude it to be tardigrade. In the Cones, on the contrary, the foot is small and of weak muscular power,—yet so rich is all creation with proofs of contrivances adapted to annul a defect, that we might anticipate to find some remedy here,—and it is so. The mouth of the snail is situated in a cavity, and this cavity it applies to aid its weakness; for it performs, like the oral aperture of the leech, the office of a sucker, by which the head is readily affixed to foreign bodies. Thus the animal facilitates its progress, and is enabled to drag along the shell, of a weight and size otherwise quite burdensome to it.*

The foot of Gasteropods is mostly of a uniform structure throughout,—that is to say, its muscular fibres are interwoven much in the same manner as they are in the human tongue, and are not collected into distinct and separate bands. There are, however, several considerable exceptions to this. In the slugs and snails progression is performed by a pair of muscles which extend from the tail to the fore part, running along the middle of the foot, while the sides are formed of strong transverse fibres; in the Pedipes and its allies there is a transverse muscular band under the neck which separates the foot into an anterior and posterior portion; and in some land-snails (Cyclostoma) the foot is divided longitudinally into two equal halves. By a series of undulations propagated along the sole, or these muscular bands, from the tail forwards to the head, occupying sometimes the whole surface, and sometimes the middle only, and resembling, to use the apt comparison of Swammerdam, "the waves and bil-

* Adanson, Sénégal, 89.

lows of the sea," the Gasteropod moves forward in a continuous manner, marking its track, in the land species, with a silver line of concrete slime exuded to smoothe the asperities of the road.* You cannot fail to have noticed the snail in its pilgrimage; and the aquatic tribes progress in precisely the same way, whether they slowly traverse the floor of ocean, or climb the rugged steeps of the rock, or stray amongst their groves of sea-weed and coral. Those which, like the Helices and Trochi, have conical shells flattened at the base, carry them upright; but when the shell is fusiform or turreted, it is usually trailed in nearly a horizontal position, with the point always directed backwards. The Cyprææ, when they walk, cover their shell with the lateral lobes of their cloak, which are very often beautifully and vividly marked with various colours; and many other mollusca cover their shells more or less completely with similar expansions. But the Pleurotoma virgo is the most singular of all in this respect. According to Argenville, when this mollusk creeps it elevates and sustains its shell and cloak upon a rather long peduncle or stalk, which rises vertically from the back. In consequence of this remarkable position of the shell, the animal tumbles over at every impediment; but it heeds not, quietly resumes its proper attitude, and pursues the road.† And with like awkwardness the Strombidæ and some other genera, as Rostellaria and Phorus, march along. The foot is narrow, but powerful and elastic; and in progression the animal places it under the shell in a bent position, when suddenly, by a muscular effort, it straightens that organ and rolls and leaps over and over.‡

You are aware, undoubtedly, that a snail touched when on a journey instantly contracts its members, shrinks within itself, and stops for a time; and this fearfulness is a very general attribute of the class, in some carried to such an excess that your patience in watching is exhausted ere they will again shew themselves out of their shells:

> "Or, as the snail, whose tender horns being hit,
> Shrinks backward in his shelly cave with pain,
> And there, all smother'd up, in shade doth sit,
> Long after fearing to creep forth again;
> So, at his bloody view, her eyes are fled
> Into the deep dark cabins of her head."

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* Lister has given a very clear explanation of the action of the foot in his Exercit. Anat. de Cochleis, 153. See also some remarks by Mr. Main in the Zool. Journ. iii. 599.

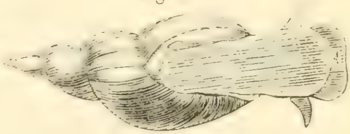
† Proc. Zool. Soc. 1847, pp. 22, 23.

‡ Lam. Anim. s. Vert. vii. 90.

I have noticed that the Valvata, when in confinement, will remain days shut up in this manner; the Limnæus stagnalis is less obstinate, but still a great alarmist; while the Physæ, nearly allied to the Lymnæus, and apparently less defenceless, are only momentarily arrested by a touch, when they again extend themselves and go on unhesitatingly. But the Helicolimax Lamarckii—a terrestrial species—affords quite an exception to the general rule, for "if disturbed or irritated it only crawls the faster; and if at rest and contracted, it directly puts itself in motion on being touched or disturbed." * The Nanina, an East Indian land mollusk discovered by Mr. Benson, has the same habit as the Helicolimax. †

All Gasteropods are not confined, however, to crawl on the solid bottom: many of them can ascend to the surface, and make the water a liquid pavement, along which they creep in the same manner as they do on land, with the difference only of having their body and shell in a reversed position. The Aplysiæ, and many of our nudibranchial mollusca, may be seen crossing pools on our shore in this way; and there is reason to believe that all the marine naked mollusca possess the faculty. ‡ When I have confined a number of the minute Rissoæ, so common on our coasts, in a glass of sea-water, some have very soon suspended themselves from the surface; but it is the freshwater snails (Mollusca pulmonifera) which exhibit this not unremarkable mode of progression in the most perfect manner. On a summer's day any one may see the Limnæi (Fig. 21) and Planorbes thus traversing the surface of ponds and ditches in an easy undulating line; § or suspended there in luxurious repose, perhaps—

Fig. 21.



> "To taste the freshness of heaven's breath, and feel
> That light is pleasant, and the sunbeam warm."

* Lowe in Zool. Journ. iv. 342.

† Proc. Zool. Soc. 1834, p. 89.

‡ Risso, l'Europ. Mérid. iv. 39, 47.

§ Müller says that in this position no motion of the foot is perceptible. "In fluviatilibus nulla quidem undulatio percipitur; ope tamen occultæ rotationis vel ignoto mechanismo nec lentius, quam terrestres, progrediuntur."—*Hist. Verm.* ii. pref. xx. Lister had previously made the same observation.—*Exercit. Anat. de Coch.* 153.

Quatrefages is of opinion that the progression of mollusks in this reversed position on the surface of the water, cannot be made by any muscular

When thus suspended they will sometimes relax their hold and drop at once to the bottom, from which, in general, they emerge by crawling up some solid body; but occasionally I have seen them rise up direct through the water—a fact I can explain only by supposing that they have the power of compressing, in the first instance, the air in their pulmonary cavity, and of again allowing it to expand and dilate so as to render the body lighter than the medium in which they live.*

There are many exceptions in the class of Gasteropods, as I have already told you, to our general description of the foot, and these necessarily draw with them certain peculiarities in the habits of the animals. In some genera (Pedipes, Assimenia), the foot is divided by a transverse groove into two unequal halves; and in others, the place of the groove is occupied by a muscular band distinguished by its greater density and opacity. The latter structure is to be observed in some common Rissoæ, which seem, however, to progress in the usual fashion, but the structure affects the Pedipes remarkably. When it desires to advance it makes fast by the posterior half of the foot, and carries forward the anterior half as far as the groove (which relaxes considerably) will permit; then the creature draws forward the posterior half so as to touch the anterior, and thus the body is advanced a space equal to that which separated these points. This first step made, it begins a second,—taking as the point of support the posterior half, while the anterior is pushed forwards, and when this is fixed in front, again dragging towards it the posterior one. This movement, similar to that of certain caterpillars, is executed with such quickness that few mollusks excel the Pedipes in alertness.† The locomotion of the Pupa pagodula is not very unlike this, but the structure of the foot does not show the same peculiarity. The snail is remarkably small in proportion to its shell, the relation between them being made good by the superior strength of the muscles of the foot, and of the

action of the foot; and he ascribes the motion to the action of the vibratile cilia which cover the entire body, as well as the sole of the foot.—*Ann. des Sc. Nat.* (1843), xix. 309. I cannot assent unhesitatingly to this explanation, for it seems to me, irreconcileable with some of the phenomena. An Eolis crossing a basin can at once stop, and remain there for any time; but during all this period of rest, the cilia are in as active a state as when the creature was in motion.

* In the Ampullaria it is said that there is a large pouch in the roof of the respiratory cavity, which is filled with air, and must serve as a kind of buoy or swimming-bladder.

† Adanson's Senegal, 13, and Introd. li.

pedicle which intervenes between the insertion of the foot and the body. In walking, the aperture of the shell is placed plumb on the back, while the spire is laid horizontally, directed obliquely to the right, and raised just high enough to avoid contact with the body. This position of the shell is sufficiently singular, but the action of the foot is more so, for at each effort in progression the tail is raised a little, and then beat against the plane of motion to give a greater impulse to the foot, or, as it were, a push to the body, while two wide undulations only pass rapidly from the tail forwards to the head.* A structure the very reverse of that of the Pedipes is met with in the Phasianella, so named because of the beautiful pheasant-like disposition of the colours on the shell. MM. Quoy and Gaimard, who had many opportunities of studying the large species peculiar to the coasts of New Holland, tell us that when these Gasteropods creep, their foot appears to be divided by the mesial line into two lateral halves which advance alternately: when the right side moves the left remains stationary, and when this is carried forward, the other half of the foot serves as a point of support. Audouin and Milne Edwards have discovered that the little species of the same family found on the shores of some parts of France, exhibit the same peculiarities in their mode of progression, which, they say, may be compared, to a certain extent, to the amble or canter of the horse; † and you may hope that, in some future day, you shall verify the observation, for we have a Phasianella indigenous on our southern coasts.

The Gasteropods which are sea-born, and which live more on the ocean than on the coasts, have in general certain auxiliary appendages to the foot,—sometimes so highly developed as to become indeed the principal means of their movements. The Aplysiæ, the Aceres, and the bulk of the Mollusca nudibranchia, require the aid of such appendages, for they are liable to be carried away from their littoral haunts by storms, or on floating sea-weed, into deeper water, where they must avail themselves of the fin-like expansions of their cloaks as adjuvants to the power of their foot. Some of them appear to have been created expressly to dwell amid the fields of the floating gulf-weed; for the foot has been lengthened, and narrowed, and channelled down its middle, so that it may receive the slender frond of the weeds in the furrow, and give a firmer grasp and security to the creature. Of this beautiful adaptation the Scyllæa affords a good

* Michaud's Supp. to Drap. p. 60. † Litt. de la France, i. 135.

example; and as the Notarchus (molluscans nearly allied to the Aplysiæ) are weaker of frame, they have, in addition to this furrowed foot, a small sucker in front of it, analogous in form and use to the sucker of the Nucleobranches,* which they otherwise resemble in their manners. Other allied Gasteropods, still more pelagic, float even on the wave; and the foot, having become useless, does either not exist, or exists merely in a rudimentary condition; while, on the contrary, the pallial appendages deserve the name of fins from their developement and use. Thus in the apodal Pterosome a thin membrane surrounds the whole body, which it sustains by the extent of its expansion, and displaces by its muscular movements; but in the Glaucus and Briareus, the expansions are divided and extend horizontally on each side. You will remember that, like the more normal species, all these swim constantly in a reversed position, having the foot, or ventral surface, applied against a thin layer of water which intervenes between it and the atmosphere.†

But unquestionably the most remarkable apparatus for locomotion among the Gasteropods, is offered for our contemplation by the Ianthina, a snail-like mollusk, with a light and purple-coloured shell, the native, it is believed, of tropical seas, though one species has been so frequently found on our own coasts, that its claim to be considered a native is now generally admitted. Its proper habitat is the open sea, where it has the power of swimming at the surface at a slow rate. To the posterior part of the foot there is attached a large vesicular appendage, very aptly named *spuma cartilaginea* by Fabius Columna, for the vesicles are as transparent as the air-bubbles in foam, while the skin is cartilaginous or membranous.‡ Buoyed up on these air-

* Rang's Man. p. 28. † Ibid. p. 24.

‡ Dr. Reynell Coates gives the following description of the mode in which this organ is constructed or repaired: "Individuals being placed in a tumbler of brine, and a portion of the float being removed by the scissors, the animal very soon commenced supplying the deficiency; the foot was advanced upon the remaining vesicles, until about two-thirds of the member rose above the surface of the water; it was then expanded to the uttermost, and thrown back upon the water, like the foot of a Lymneus when commencing to swim; in the next place it was contracted at the edges, and formed into the shape of a hood, enclosing a globule of air, which was slowly applied to the extremity of the float. A vibratory movement could now be perceived through the foot, and when it was again thrown back to renew the process, the globule was found enclosed in its newly constructed envelope. From this it results that the membrane which encloses the cells is secreted by the foot, and that it has no attachment to the animal other than the close adhesion resulting from the nice adaptation of proximate surfaces." —*Zool. Journ.* iii. 264; *Ann. Phil.* n. s. x. 385.

bladders, the Ianthina floats at ease,—not left, however, to be driven at random by every current or breeze which may sweep across its path, for its course is guided by means of a small fin, which runs along each side of the foot a little above its edge. It is only when the "tempest's breath" blows hard that the snail yields to its violence, and suffers wreck on the unfriendly shore. Of this interesting mollusk Dr. Browne says, that "it probably passes the greatest part of life at the bottom of the sea, but rises sometimes to the surface." * On the contrary, all recent observers assure us that it has no power of even sinking in the water. The opinion of Browne long prevailed, and we were told that the air-bladders could be thrown off and renewed at pleasure, as the animal wished to sink or rise. Nor am I convinced that this is an erroneous supposition, for certainly the vesicles are often found swimming detached. Cuvier supposed that the snail might be able to compress the apparatus to such a degree as to allow its withdrawal within the shell, when the body would sink by its own weight, and that it would rise again when the snail relaxed its muscular efforts by the natural elasticity of the gaseous contents expanding the vesicles to their full volume.† This conjecture Mr. Bennet has disproved. He found that when the Ianthina was purposely irritated, it had no power of retracting its float:—"On the animal being touched, in ever so slight a degree, it produced the effect of causing it immediately to withdraw itself into the shell, and even at first, on any person moving near the glass of water in which it floated; but then the frothy appendage always remained stationary." ‡ Nor is the float, although undoubtedly the buoyancy depends in a great measure on it, essential to the support of the snail at the surface, for Dr. Browne and Mr. Bennet frequently captured specimens there which had it not; whence the latter infers "that they can float on the surface of the water equally with or without it, although it must be naturally supposed that the animal and its shell cannot be retained so long on the surface without as with it."

The connexion of this organ with the foot does not appear to be organical; it is merely fixed in its place by some albuminous secretion, and can be detached without any laceration or wound. The nature of this connexion between the parts greatly supports the conjecture that the animal may cast it off after a season by a natural exfoliation,

* Hist. of Jamaica, p. 400. † Mem. xv. 5.

‡ Med. Gazette for 1834, p. 233. Also Grant in Proceed. Zool. Soc. iii. 14.

when it may sink to the bottom for a certain time; for, notwithstanding all that has been lately said, I am inclined to go into Dr. Browne's belief of its living there; and am not unwilling to believe further, that its floating may be during the breeding-season only, for, as we shall afterwards see, the vesicular appendage is likewise a sort of ovarian receptacle. It is no substitute for an operculum, as Cuvier states,* because it does not adhere in the same manner, nor in the analogous place; for instead of being situated above the posterior part of the foot, it is below:† the organ is, in fact, a special contrivance made for a specific use.‡

The habits of the Litiopa are not less worthy of your notice. This is a small snail, born amid the gulf-weed, where it is destined to pass the whole of its life. The foot, though rather narrow and short, is of the usual character, and, having no extra hold, the snail is apt to be swept off its weed; but the accident is provided against, for the creature, like a spider, spins a thread of the viscous fluid that exudes from the foot, to check its downward fall, and enable it to regain the pristine site. But suppose the shock has severed their connexion, or that the Litiopa finds it necessary to remove, from a deficiency of food, to a richer pasture, the thread is still made available to recovery or removal. In its fall, accidental or purposed, an air-bubble is emitted, probably from the branchial cavity, which rises slowly through the water, and as the snail has enveloped it with its slime, this is drawn out into threads as the bubble ascends; and now, having a buoy and ladder whereon to climb to the surface, it waits suspended until that bubble comes into contact with the weeds that everywhere float around! § From the observations of Mr. Gray, it appears that the Rissoa parva of our coasts had somewhat similar habits;|| and the Cerithium truncatum, which is generally found in brackish water in mangrove swamps and the mouths of rivers, does sometimes suspend itself from the boughs and roots of the mangrove by a glutinous thread.¶ We have also a native lacustrine species, the Physa fontinalis, which can let itself down gradually, like the Litiopa,

* Mem. xv. 4. See also Proc. Bost. Soc. N. Hist. i. 21.

† Rang, Man. p. 25.

‡ "Mr. Parkinson rightly conjectures that the shells resembling the Helix, or snail, in the older strata, were constituted for swimming, like the Ianthina: they could scarcely have used a foot for crawling at the bottom of a deep and agitated ocean."—*Bakewell's Geology*, p. xxxv.

§ Rang's Man. pp. 26, 198. Kiener in Ann. des Sc. Nat. xxx. 223.

|| Proc. Zool. Soc. iii. part i. 116.

¶ Mag. Nat. Hist. n. s. iii. 127.

by means of a glutinous thread affixed to the surface;* and many land slugs have been seen to spin a line from the gummy secretion of their skin, and thus descend, from trees and precipices, by a shorter route than that by which they had ascended.†

Our second class of Crawlers embraces the bivalved mollusca, or at least the great majority of them, for the Monomyairians in general have no foot, and are consequently incapable of locomotion. The foot, where it exists, varies greatly in size and figure,‡ accompanied always, of course, with corresponding variations in the mode or velocity of progression, but in general it is of an oblong shape, often with a bend in the middle, and more or less compressed. (Fig. 22.) Attached to the abdominal and middle part of the body, more or less in front, it can be moved in nearly every direction, more especially forward, shortened or lengthened, bent or made straight, by the action of its interlaced texture of muscular fibres; and it can be drawn at will within the valves, or protruded beyond them, by other muscles, which run towards different points of the shell where they are inserted. Its length is often surprising. I have seen a small individual of the Crenella discors put forth a foot at least six times longer than the shell, which, nevertheless, when not in action, was so neatly folded up and contracted within it that no part was visible.

Fig. 22.

Bivalve mollusca proceed at a rate even slower than that of any snail, and, perhaps, seldom attempt the exercise, unless driven by some urgent want. One species only (Psammobia aurantia, *Lamk.*) is certainly known to creep like the Gasteropods, although, from the structure of the foot, it has been conjectured that some Arcæ likewise do so.§ The rest, when bent on change, leisurely protrude the motive organ, extend it to the utmost, apply it with hesitation and care to a solid surface, and then, by contracting it, as with a painful effort, they jerk forwards the body and its testaceous envelope. Now the foot is again extended in the same cautious manner, and the shell again dragged forward

* Montagu, Test. Brit. p. 227.

† Megalomastoma suspensum has derived its trivial name from the habit the animal has of suspending itself by glutinous threads. It is a native of the woods of St. Vincent. See Swainson's Malacology, 186, fig. 29.

‡ Proc. Zool. Soc. 1847, p. 21.

§ Blainville's Man. p. 151. The Nucula, a genus of the Arcadæ, is now known to creep like a Gasteropod.—Forbes and Hanley, *Brit. Moll.* ii.217.

to the point of fixture. Such is the manner in which I have seen the Cyclas, an inhabitant of our ponds, and some of the lesser Bivalves which inhabit our shores, move along; and, I presume, it is in a similar manner that the other and larger species proceed. Reaumur has happily compared their mode of progression to that of a man who, having laid himself flat on his belly, desires to move onward by the sole aid of his arms: he stretches the arm to a point of support which he can just reach with the hand, and take hold of, when, by shortening the arm, he drags his body on; and the foot of the Bivalves differs from the arm only in this, that the shortening is effected by a general contraction of the muscular fibre, and not by muscles bending a joint.* Reaumur also informs us, that some Bivalves, as the Myæ, can move retrogradely along the ground in this manner. They plant the point of the foot just beyond the margin of the valves in the clay or mud, and then by elongating the foot, they push themselves backwards, in the same way that a sailor pushes off a boat by leaning against the oar which he has planted in the sand on one side.

When the bend in the foot of a Bivalve is considerable, forming a sort of elbow, the animal is projected forward by a succession of short leaps. Such a structure characterises the Tellinæ and Donacidæ, and you may see it well marked in the Donax trunculus of British authors, a species which is abundant on most of our sandy shores. When it is about to make a spring, it firstly, by appropriate motions of the foot, puts the shell on the point or summit, as if aware that this is the position the most favourable of any to avoid the resistance which the sand opposes to the motion. It then stretches out the leg as far as possible, makes it embrace a portion of the shell, and, by a sudden movement, similar to that of a spring let loose, it strikes the earth with its leg, and effects the leap.† This, in some species, is considerable, for Mr. Sutchbury told the Rev. Mr. Kirby that Trigoniæ of New Holland would leap over the gunwale of a boat, to the height of above four inches.‡ Some Clams or Pectens, and the closely allied Limæ, are also salient; but their leaps are the result of a sudden strong effort to close the valves, after they have been opened to the utmost,§ and which the remarkable size of the adductor

* Mém. de l'Acad. Roy. des Sc. an. 1710, p. 581.

† Smellie's Phil. Nat. Hist. i. 138; but more particularly Reaumur's memoir just quoted, p. 600.

‡ Bridgew. Treat. i. 264.

§ Of Pecten islandicus Fabricius says, " Editur quidem ab incolis, sed raro. Difficulter etiam coquitur: cum testa enim vivus vasi coquinario

muscle enables them to do with great vigour.* When deserted by the tide on any occasion, they will tumble forward in this way until they have regained the water. Nay, some popular writers repeat a story from the ancients, that these scallops, by flapping their valves with a very quick motion, can rise up from their beds in the deep, and navigate the surface, having one valve raised and exposed with its concavity to the breeze, while the other remains under the water, and answers the purpose of a keel, by steadying the animal, and preventing its being overset. What degree of faith you are to place in this account I will not positively say, but I think it probable that the sailing part of it is an embellishment thrown in by way of effect, while there can be no doubt of the Pectens' vivacity, at least in its early state of existence.† Our excellent friend the Rev. David Landsborough writes thus: "We observed on a sunny September day, in a pool of sea-water, left on Stevenston strand (Ayrshire) by the ebbing tide, what we at first thought some of the scaly brood at play. On close investigation, however, we found that it was the fry of Pecten opercularis skipping quite nimbly through the pool. Their motion was rapid and zigzag, very like that of ducks in a sunny blink, rejoicing in the prospect of rain. They seemed, by the sudden opening and closing of their valves, to have the power of darting like an arrow through the water. One jerk carried them some yards, and then by another sudden jerk, they were off in a moment in a different tack. We doubt not, that when full-grown they engage in similar amusements, though as Pectens of greater gravity, they choose to romp unseen, and play their gambols in the deep."§

immissus vi elastica exsilit."—*Faun. Groenl.* p. 416. See also Arist. *Hist. Anim.* l. 4, cap. iv.

"Les Limes volent, pour ainsi dire, dans l'eau par les battements brusques et réitérés de leurs valves. MM. Quoy et Gaimard, qui firent partie de l'expédition autour du monde commandée par M. Dumont d'Urville, racontent qu'ils furent obligé de courir après des Limes pour s'en emparer."—Chenu, *Leç. Elément.* 101.

* Lister, Exer. Anat. tert. auct. p. xlii.

† Kirby regards the Pectens as, in some degree, the analogues of the butterflies amongst insects, "and their flying, as it were, on the surface of the water" increases the resemblance!—*Bridgew. Treat.* i. 254. This seems to us a rich example of a false analogy.—Bosc affirms that some of the genus Venus can sail in the manner ascribed to the Pectens.—*Hist. des Coquil.* iii. 41. And the Rev. Mr. Guilding discovered a genus allied to Lima which swims "with as much ease as a fish," by opening and closing the valves, and the action of the tentacular fringe of the cloak.—*Mag. Nat. Hist.* ix. 194.

§ Scottish Christian Herald, ii. 165: "At the age we saw it perform,

I had intended to have concluded my account of the Crawlers with this interesting passage, connecting, as it does, the tribe with the swimming Pteropods, but it somehow reminds me that I have omitted to mention that some fluviatile Bivalves, as Cyclas and Pisidium,† and some marine species (Kelliæ, Amphidesmæ) allied to them in character and bulk, have the same power as the Lymneæ, of ascending to the surface of their ponds, or pools, and traversing them from side to side, in a reversed position, as though they were crawling along a solid plane.

it was only about the size of a silver groat." See also Landsborough's Excursions to Arran, p. 189; and Strickland on the Movements of the Lima, in Mag. Nat. Hist. n. s. i. 28. The Bulla akera, in a young state, has the resemblance of a winged insect, and sports in the water with all the liveliness of a butterfly, forming a pleasing object when kept alive in a glass.

† Jenyns in Trans. Camb. Phil. Soc. p. 12 of the separate Monograph. Macgillivray's Moll. An. Aberd. p. 251. Mery asserts the same of the fresh-water mussel. Hist. de l'Acad. Roy. des Sc. Nat. 1710, p. 538.

*Addition to note * of page* 125.

In a letter to Professor Owen, in the Report of the Transactions of the Sections of the British Association for the Advancement of Science for 1844, p. 77, Madame Power gives a still more particular account of the locomotion of the Argonaut: "It would be difficult to describe the immense variety of the movements of the Argonauta argo in swimming, dragging, and floating, and it would require a series of drawings to represent them: these movements vary according to the fancy or caprice of the animal, or to circumstances; for instance, when at the bottom of the water, and wishing to rise or go in any other direction, the only movement it makes is to agitate its siphon, and thus it swims with its body and eight arms hidden in the shell; or it swims with its mantles totally or in part extended over the shell; or holding a portion of the body more or less above the shell; or holding its prey with its arms. The Argonaut also drags itself along the sand, gravel, or mud, at the bottom, or climbs millepores and madrepores in search of mollusks or other nutriment, or when it seeks concealment; it sometimes anchors by its lower arms, hanging from the shell and attached by their suckers."

LETTER IX.

THE BURROWING AND STATIONARY MOLLUSCA.

My last letter concluded with some account of the locomotion of certain of the Bivalve Mollusca, but you must now be told that the great majority of this class reside habitually in furrows which they have excavated in the gravel, sand, or mud, where they live concealed from their foes, and protected against the rudeness of the sea, which would otherwise cast them helpless on the shore, as you must have noticed is frequently the fact when the storm has been sufficiently severe to remove the under-soil. Then is the time for the Conchologist to take his walk; and he will do well to guide himself in his search for the objects of his study by noticing where the crows and sea-birds are principally congregated. The Solenes and Tellinidæ prefer fine sand to work in, the Myades and Lutrariæ coarse gravel, and the Cardia are often found in sludge. Some dig scarcely deeper than just to cover and conceal themselves; others penetrate to a depth of one or even two feet, ascending and descending in the furrow with a velocity rather surprising for creatures so habitually sluggish. They effect these motions by varying at will the length and form of the foot, the same organ with which they had in the first instance dug their furrow. When the animal would burrow, it projects and elongates the foot, distending it until every part of it, except the point, appears semi-transparent. Directing its point downwards, it insinuates it into the sand until it is nearly buried. A circular motion is now given to the shell, by which its anterior point is quickly brought nearly into contact with the foot, and immediately returned to its former situation. It thus moves on the foot, as on a fulcrum, with a see-saw motion. The foot, which had been partially retracted, is again gradually projected as far as possible into the sand, when the circular motion of the shell is repeated. When the animal is moderately active, the strokes follow each other at intervals of twenty or thirty seconds. The apparent progress is at first but small,—the shell, which is raised on its edge at the middle of the stroke, falling back on its side at the end of it; but, when the shell is buried

so far as to be supported on its edge it advances more rapidly, sinking visibly at every stroke, till nothing but the extremity of the siphons can be perceived above the sand.* These motions of the foot and shell are effected by two pairs of muscles, which arise from the shell and are inserted into the foot, which they embrace; but this organ, in some genera, is likewise perforated to near its point with a tube, which, opening just within the mouth, conveys water to distend and stiffen it. In some of the largest species, as in Cyprina islandica, a transverse section of the foot shows a single chain of pores along its whole length, which communicate with this tube, and transmit the water to the cellular portion of the foot; and, when thus distended, a viscid matter is secreted from its surface, which, by agglutinating the sand around it, fixes it more firmly, and thus augments the force of the stroke.

These burrowing tribes never, I believe, voluntarily quit their cells; and, if torn from them by the action of a stormy sea or any other cause, they rarely, when full grown, attempt to re-bury themselves.† But there is a species of Gasteropod, which, generally living on the surface, has yet the power to burrow, and does so, it would appear, habitually when in search of prey. This is the Whelk (Buccinum undatum), so common on our coasts. "As in the Bivalves inhabiting sand, its foot is the instrument of penetration; and, like them, it has the power of distending this organ to

* "By the action of this foot these animals can bore with great facility in the sand, where some are found at considerable depth. They can likewise accomplish a quick progression, by using it as a hook, or pushing themselves forward by its means; they also swim on the surface of the water, by expanding it into a concave dish, and climb perpendicular surfaces by fixing its extremity like a sucker. Some species have the power of secreting air into two sacs of the mantle, attached to the excretory organs, by which their specific gravity is diminished; and they readily change their situation at the ebb and flow of the tides."—Garner in *Charlesw. Mag. Nat. Hist.* iii. 128.

† "If the Solen be taken out of its hole and placed upon the sand, it immediately prepares to re-bury itself. It stretches out its foot to full length, and then bends it so as to use the extremity as a kind of auger. When the end has sunk into the sand, it draws up its shell, which, first oblique, and afterwards perpendicular, soon becomes immersed and rapidly disappears. M. Deshayes, during his Algerian researches, observed a remarkable instinct of Solen marginatus to swim, when desirous of changing its locality. When it finds itself on ground too hard to be penetrated by its foot, it fills the cavity of its mantle with water, and then contracting, and closing exactly at the same time its siphonal orifices, elongates its foot; then re-contracting that organ, it ejects the water with force from the tubes, and thus propels itself after the manner of a cuttle-fish, for a foot or two forward. Then, if it finds the surface favourable, it bores and buries itself; but if not, makes another leap to try its chance anew."—Forbes and Hanley, *Brit. Mollusca*, i. 245.

a size nearly, if not quite, equal to that of the shell." "The moderately distended foot can scarcely be retracted within the margin of the shell; and when fully injected, it is elastic, and of a very large size. The cavity which it opens into the sand is therefore fully adequate to receive the shell, which is drawn down into it by the contraction of the muscle of the spire. From the attachment of this muscle the spire is the part more directly acted upon, and which is depressed in the greatest degree. Hence the notch is always uppermost; and the Buccinum, when completely buried, is enabled to communicate with the water by its respiratory siphon." The habits of the Cassides, or Helmet-shells, of Cymbium, of the Naticæ, Bullæ, and of several others amongst the carnivorous tribes of Gasteropods are similar to those of the Whelk, and they have a foot of similar structure.

The locomotion of the burrowers is then of a restricted character, confined chiefly to partial movements in the furrow, but they are not prevented by a physical hinderance from the ability of removal, if a strong necessity should urge it. Another tribe, of greater interest, unable to burrow, and yet from their littoral habits much exposed to the sea, willingly secure their ease and safety by a sacrifice of liberty.* Foremost amongst these are the genera which moor themselves to the rocks by what the vulgar call the beard of the fish, and the learned its byssus. Such are the Mussels, the Hammer-shells, the Pinnæ, the Pectens, and a few others of less common note; but these others of lesser note illustrate a very general rule observable everywhere on the introduction of any new mode in the economy of animals, that the mode is never done abruptly. So here we find mollusks that make, as it were, an essay of the utility of a byssus before the resolve to become anchorites is taken up by others. The pretty family, Kelliadæ, spin occasionally a feeble byssus, and of few threads, by which they attach themselves temporarily only, for they can unfix themselves again at pleasure, and do so repeatedly during the course of their lives.† And the Tapes pulastra, which is usually free, for

* "Travelling is not good for us, we travel so seldom."—"How much more dignified leisure hath a mussel, glued to his impassable rocky limit, two inches square! He hears the tide roll over him backwards and forwards, twice a day (as the Salisbury long coach goes and returns in eight and forty hours), but knows better than to take an outside place a-top on 't. He is the owl of the sea, Minerva's fish—the fish of wisdom."—Lamb's *Letters*, Edited by Talfourd, i. 319.

† Forbes and Hanley, Brit. Mollusca, ii. 70, 78, 79.

I have often found it so, and never moored, if placed in a situation where it would be liable to be carried away by the current, averts the fatal wreck by attaching itself by some filaments to the shingle or stones around it.* Of the curious Lepton squammosum my worthy friend Mr. Alder thus writes:—" As may be imagined from the size of the foot, it has the power of crawling about very freely, and sometimes it also swims inverted on the surface of the water in the manner of the Gasteropods, the hinder part of the foot being then unfolded into a disc; but its favourite position is that of repose, suspended freely in a perpendicular position with the umbones downwards, by three or four threads, so fine that they cannot be seen by the naked eye, and even with a magnifier can only be observed in certain positions of light. The byssal aperture appears to be about the centre of the foot."†—Even when the species have become habitual spinners, and are rarely found unattached, yet do some of them retain the power to loose their hold, and go in search of another locality. I am certain that this is the case with two of our small Crenellæ; and some years ago Dr. Augustus A. Gould, of Boston, in a letter to me, said: " I have made one observation, which so far as I can learn from books, has not been observed by others. It is generally stated that the Mytili are stationary, and have no other motion than the oscillatory one which their byssus allows. By keeping some in a jar of water I have been enabled to determine that they move from place to place with great facility. The annexed diagram (Fig. 23) may give you some idea of the successive stations they take. Three or four of these stations will be taken in a single night. They detach themselves by casting off the whole of their cables at the gland from whence they all radiate, leaving the distal ends still attached, apparently holding on in the meantime by a single thread till they secure themselves in a new station."‡

I must here interrupt the subject by a little space, to tell you how ingeniously man has applied the spinning instinct of the mussels to his purpose:—" At the town of Bideford, in Devonshire, there is a long bridge of twenty-four arches across the Towridge river, near its junction with the Taw. At this bridge the tide flows so rapidly that it cannot

* Forbes and Hanley, Brit. Mollusca, i. 386. † Ibid. ii. 101.

‡ See also, Proc. Bost. Soc. N. Hist. i. 72. A good figure illustrative of these movements of the mussel may be seen in Ann. des Sc. Nat. (1842), xviii. pl. 3, fig. A. 1.

be kept in repair by mortar. The corporation, therefore, keep boats in employ to bring mussels to it, and the interstices of the bridge are filled by hand with these mussels. It is supported from being driven away by the tide entirely by the strong threads these mussels fix to the stonework; and by an act, or grant, it is a crime liable to transportation for any person to remove these mussels, unless in the presence and by the consent of the corporative trustees."*

Fig. 23.

The byssus consists of a bundle of horny fibres or threads, connected to the animal within the shell on the one hand, and to the rock on the other. How this connection is effected was first discovered and explained, in his usual copious and clear manner, by Reaumur. By placing mussels (Mytilus edulis) in vases of sea-water, he found the following to be their manner of proceeding. Opening their valves, the foot was first protruded, and, with various strains and stretches, gradually thrust out, until at length the elongation was carried to the desired extent, sometimes to fully two inches. It was now employed in feeling or testing all the objects within reach, directed or to the right or left, backwards or forwards. After all this prelude, to ascertain, apparently, the security of the intended holdings, the point of the foot is settled and retained for a short time on the chosen spot, when it is again suddenly removed, and immediately withdrawn entirely within the shell, leaving behind a thread that reaches from the spot to the base of the foot. By many repetitions of this operation, carried on patiently day after day (for not above four or five threads are spun in the twenty-four hours), and by attaching the disk-like extremities of the threads to different places, the mussel at last completes its cable and secures a safe anchorage.† The an-

* Drummond's Letters to a Young Naturalist, p. 39. Patterson's Intr. Zoology for Schools, i. 170.

† The threads are frequently affixed in straight lines, and at short but equal distances; and the circular disks appear then very plainly, especially on the surface of a bivalve shell. Leeuwenhoek asserts that the disks adhere to the foreign body partly by the pressure of the atmosphere, and partly because no air or water can gain admittance between the stone and the disk,—

nexed figure may assist you in comprehending the process. (Fig. 24.) There *d* represents the organ by which the byssus is fixed; *c*, the byssus itself, with some of its fibres glued to the stone; and *a*, *b*, the muscles by whose contraction the foot is pulled within the shell from its state of extension.

Fig. 24.

The structure of the foot, or spinner,* as it might more properly be called, is exquisitely adapted to its purpose. Situated between the mouth and the byssus, it is distinguished by its tongue-like shape, its flexibility, its powers of elongation and contraction, and, in this species, by its deep violet colour. There is an open furrow traced along its middle, capable of being converted into a closed canal at will, down which the gummy fluid, from which the threads are spun, flows. This comes from a gland, or glandular parts, situated at the base of the foot, where it is secreted, and wells out when required, being formed into threads in the furrow or canal.† You perceive from the figure that the byssus of the common mussel resembles a fibrous root, originating in a single stalk, that divides in a very irregular manner; but the byssus of the Modiola, and more especially of the Pinna, is more accurately represented by a camel-hair pencil. In the former the root of it is invested with a simple fleshy sheath; in the Pinna the sheath contains five muscular leaflets, which act as partition-walls to four laminæ of nearly the same size and figure as the others (Fig. 25), but composed of a close tissue of interwoven threads, by the separation and unravelling of which, and

just as a boy's leather sucker is made to fix itself to a flat stone (*Select Works*, i. 78); but this is not the case: the threads of the mussel are attached by a close glue or cementation.

* From the foot of other bivalves it is distinguished by its position and relation to the other viscera, and its mode of connection with them. Poli and Van Beneden call it the "languette," or tonguelet; Lister, the "lingua," who, with some others among the earlier naturalists, mistook it for a sexual organ.

† "This gland, of which the existence is erroneously denied by Blainville, is of a brown granular appearance: it may readily be found in the Mytilus, or Modiola, lying upon the nervous ganglion of the foot. Its duct opens into the bottom of the groove situated on the posterior surface of that organ."—GARNER in *Mag. Nat. Hist.* n. s. iii. 126.

their prolongation beyond the shell, the byssus is fabricated.

Fig. 25.

These sea-spinners, as Reaumur calls them,* begin their work in their earliest infancy; but at that period, and for some time after, if detached, they prove themselves good walkers, moving along, after the fashion of other Bivalves, by the aid of their extensile spinneret, to which the name, but not the offices, of a foot has been denied. I have already told you, that some of them can voluntarily unmoor, and go in quest of happier localities; and if forcibly torn away from their hold, they can refix the shell by the formation of a new byssus,—not by reattaching their old one, as seems at one time to have been believed.† I believe that the typical Modiolæ and the Pinnæ can at no period detach their byssus at will.

There is a genus of Bivalves, from the shape of the shell having a certain resemblance to a boat, named Arca, which contains some byssiferous species (Byssoarcæ, Sw.), and others that are affixed in the crevices of rocks by the foot itself, changed into a sort of peduncle, dilated and corneous at the extremity, to fit it for its novel function. These lead us, by a gradual transition, to other Bivalves, whose ordination it is to be rooted, like the plant, to one spot for life, and to whom a foot is denied, as indeed it is unnecessary. They are fixed in various ways; for the Author of nature, in accomplishing one and the same end, ever varies his means and workings. The oysters and Spondyli, horrid with projecting spines, adhere by cementation, that is, without the medium of any connecting membrane or ligament; the inferior valve, in its growth, becoming fixed and modelled to the foreign substance on which it lies. The Anomiæ, which in character much resemble the oysters, are fixed partly in the same way, but their chief hold is effected by the transverse muscle, which, in the form of a round ligament, passes through a hole in the lower valve, and is firmly cemented by the intervention of a calcareous or horny wafer.‡ In a somewhat similar manner the Terebratulæ

* "I could not doubt then that the Sea has her spinners in the mussels, as the Earth has in its caterpillars and spiders."

† Hist. de l'Acad. Roy. des. Sc. an. 1711, p. 152, &c. Mém. de l'Acad. an. 1717, p. 238.

‡ Burguiere says, that the Terebratulæ can detach themselves and swim

are fixed by a short ligament;* while the Ligula anatina is raised and supported on a cylindrical cartilaginous peduncle, a few inches long, and capable, apparently, of a certain degree of contraction and elongation.

Very similar in this respect to the Ligula is the mode of attachment exhibited in the Boltenia and Clavelina, genera of the tunicated mollusca that rise up on a slender stalk, which serves them for a cable, and is fixed to its stay by fibrous radicles, not unlike those of some sea-weeds. The greater number, however, of the Tunicata are sessile, adhering by a broad basis, or spread out in the manner of a crust. Thus the Distoma, Aplidium, Polyclinum, Botryllus, &c., envelope the stems and leaves of sea-weeds in a jelly-like mass, studded over with stellated figures; while the Cynthiæ and Ascidiæ grow from them, and from rocks, like morbid warts or tumours, the more like from their being covered with a rough, sometimes granular, coriaceous skin. The adhesion of all of them is permanent and very strong; so that when you attempt their removal, it must be made cautiously, and with a knife; otherwise their body, tough as it is, will certainly be torn. These mollusca, however, are born free, and in their veriest infancy even swim at large; but, unapt to roam, and careless of liberty, they soon voluntarily root themselves beside their parents, never again to remove from the natal rock.

A few Gasteropods have the same permanent fixation as the footless molluscans I have been bringing under your notice. When Rang asserts that the genus Hipponyx, and perhaps the Capulus, are the only Gasteropods in this condition,† he forgets the Vermetus of Adanson, and the Lementina of Risso. You may, perhaps, hint to me that I am likely to forget the limpets (Patellæ); but although these creatures are assuredly sedentary to a high degree, — the same individual having been seen for days, nay, even years, attached to the same spot, yet this is from choice, not necessity. "This singular attachment to a particular spot having commenced during their young state, they seldom seek another, but accommodate their shell, in its after-growth, to all the irregularities of the rocks." You know,

on the surface: "Elles ont en outre la faculté de se détacher, suivant le besoin, pour aller nager sur la surface de l'eau."—*Encyclop. Méthod.* i. 70.

* The plug of the Anomia appears to be closely allied to the byssus of the Monomyaires. It passes out of a similar notch, and not of a hole as it is often said; it is not solid like shell, but formed of numerous parallel laminæ placed side by side, somewhat like the lamellar beard or foot of the Arca, *e. g.* A. noæ. J. E. Gray, MS.

† Man. p. 28.

from many familiar trials of its strength, how firmly the animal doth adhere. Reaumur ascertained that a weight of twenty-eight or thirty pounds was required to overcome the force of it. This astonishing power in so small and hebetous an animal does not depend on the muscularity of the foot, nor on any mechanical engraining of its surface with the pores of the stone, nor on any vacuum produced under it; for Reaumur disproved all these explanations by some decisive experiments. He cut the animal from top to bottom in two halves as it stood fixed perpendicularly on the rock, and he made other deep incisions in a horizontal direction, destroying in this manner all the muscular power of its base, and all supposable vacuity between it and the stone, but the adhesion continued as firm as before the experiment. Even the death of the limpet does not destroy the cohesion. This entirely depends on a glue, or kind of paste, which, although invisible, produces a very considerable effect. If, after having detached a Patella, the finger is applied to the foot of the animal or to the spot on which it rested, the finger will be held there by a very sensible resistance, although no glue is perceptible. And it is remarkable, that if the spot is now moistened with a little water, or if the base of the animal is cut, and the water contained in it allowed to flow over the spot, no further adhesion will occur on the application of the finger,—the glue has been dissolved. It is Nature's solvent by which the animal loosens its own connection to the rock. When the storm rages, or when an enemy is abroad, it glues itself firmly to its rest; but when the danger has passed, to free itself from this enforced constraint, a little water is pressed from the foot, the cement is weakened and dissolved, and it is at liberty to raise itself and be at large. The fluid of cementation, as well as the watery solvent, are secreted in an infinity of miliary glands, with which the foot is, as it were, shagreened;* and as the limpet cannot supply the secretion as fast as this can be exhausted, you may destroy the animal's capacity of fixation by detaching it forcibly two or three times in succession.

Of the habits of the Patella, so far as they concern us at present, Mr. Lukis, of Guernsey, gives the following account:—"The locomotion of the limpet may be ascer-

* Adanson took these glands for little suckers, to whose combined action he attributed principally the animal's adhesion.—Seneg. p. 31.

In the Onchidium peronii, in some species of Doris, and particularly in the Onchidore, the foot is sprinkled over with a great number of vesicles or vesicular tubercles.—Blainville in *Journ. de Physique*, lxxxv, p. 439.

tained by marking one individual, to avoid mistake, and then observing its cautious roaming, and regular return to its favourite place of rest, where the shell will be found exactly to correspond with the surface of the rock to which it is attached. Here it will rest, or sleep, and only relax its strong adhesion to the rock when the muscular fibre becomes exhausted by long contraction, in which state a sudden blow horizontally given will easily displace it. A fact known to the fishermen and poor, who use them for food, is, that they are more easily collected in the night-time than in the day. May not this be the period of roaming for food, as well as when covered by the tide?

"The march of the limpet is slow and formal; and, whenever the cupping process is renewed, the posterior end of the shell is brought in contact with the rock, which, if of a soft nature, will receive the impressions of its denticulations." The track of an individual, placed under surveillance, was thus made visible over a space of several yards, possessing the same regularity and disposition, and was further remarkable for the constant revolution on its left.

"The tracks of the limpet on granite and other hard rocks present at first sight the same appearances; but on a closer examination they are found to differ." When first observed, in 1829, a large portion of a fine-grained sienitic rock was traced over by these shells; the remainder was plain, and appeared varnished with a thin coating of some kind of fucus, without any markings upon its surface. "As no Patellæ were at first discovered, and the isolated situation of the rock prevented any from reaching it, I was at a loss to explain these appearances; but after some search, a fissure was found at the north end, where five or six limpets had fixed themselves, each having a direct road leading to their pasturage-ground. By the help of a glass, the markings visible on the rock were discovered to be the remains of the above fucus, which had been eaten through or trodden down by these animals in their excursions, and which retained the indentures of their shells. The edge of the vegetable surface was then examined, and found to be nibbled in a circular manner, resembling the anterior margin of the shells."*

* Mag. Nat. Hist. iv. 347.

LETTER X.

THE BORING MOLLUSCA AND NEST-BUILDERS.

I MUST now beat back a little, having been led, almost inadvertently, to pass unnoticed a tribe nearly allied to the burrowers in sand and gravel, but of deeper interest. The tribe in question are almost exclusively Bivalves, and, to secure themselves, they excavate their cells in solid bodies, —in wood, hardened clay, and harder rocks,—whence they cannot again issue or be removed; their house during life, and after death, their grave. The Teredo bores his long tortuous cell in wood; the Pholades construct their more capacious dwellings in wood and in clay; the Lithodomi and Saxicavæ excavate limestone rocks, coral-reefs, and the thick shells of other mollusks; while the Fistulanæ and Clavagellæ are said to bore indifferently into sand, wood, rocks, and into shells. In general, each species confines itself to one kind of substance, but this is not always the case. Olivi says, that he has twice seen Pholades in a piece of compact lava;* the common European species of that family are found as often in timber as in clay, and some of them perforate likewise calcareous rocks. Montagu tells us, he had specimens of Gastrochæna modiolina in common limestone, in fluor, and in granite;† and Dr. Pulteney speaks of Venerupis irus as being plentiful on the Dorset coast in clay as well as in limestone.‡—They are to be found on all shores, from Greenland to the furthest Ind. Within the tropics, however, they are most abundant, and of the largest size; but the station most celebrated in history is European, viz. in the Bay of Naples, near to Pozzuolo, where a colony of Lithodomi § had settled themselves in the pillars of the temple of Jupiter Serapis during the period

* There is probably some error in this observation, so far as it would lead to the inference that the Pholas had bored into the lava. Spallanzani, who tells us that he had given particular attention to the subject, never observed the lithophagous mollusca to "make their lodgments but in calcareous stones."—*Trav. in the Two Sicilies*, i. 178.

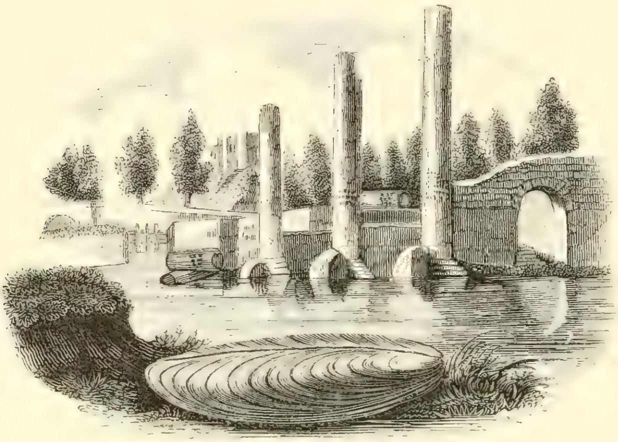
† Test. Brit. Supp. 25.

‡ Ibid. 109.

§ Bohadtch says they are Pholades which have made these excavations.—*An. Marin.* 154. But this is a mere licence of nomenclature: the species is the Mytilus lithophagus, *Linn.*=Modiola lithophaga, *Lam.*

of its submersion. At the height of ten feet above the base of the three standing pillars which remain, and in a position exactly corresponding in all, is a zone of six feet in height,* where the marble has been scooped into cells by these mollusca (Fig. 26). The holes are to the depth of four

Fig. 26.



a

inches; and it is observed that the nodules of quartz and feldspar, which sometimes occur in the hard limestone of the pillars, are untouched. In what manner this temple was submerged and again left dry has much puzzled and perplexed philosophers, and the discussion is, fortunately, beyond our province; but it becomes us to inquire by what means shell-fish make these holes, for which, apparently, they are most unfit.

The point has been much debated, and it seemed so hard to solve, that Rondeletius saw nothing for it but to suppose that the sea-water, lodging in the rocks, was itself transformed into Pholades and other saxicavous mollusca; and other philosophers, as Mr. Bingley good-naturedly calls them, were driven to the belief that they entered the rock while it was yet in a soft state, which afterwards hardened by degrees around them. Two explanations of the process

* Spallanzani says that the height from the ground is about nine feet, and that the perforated band is only "about two feet in breadth." Two species of Mytilus or Modiola and "other lithophagous worms" have worked to produce it.—*Trav. in the Two Sicilies,* i. 84, 85.

had for long divided less imaginative naturalists,—the one, that the creatures bore by the aid of a solvent liquor which they excrete; the other, that they do so by processes, or hard portions of the shell, worked by its semi-rotatory motions, and regulated by appropriate muscles. Of late, other two theories have been propounded: the borings have been ascribed, by an ingenious author, to the action of currents of water, directed against the parts to be worn away, by the ceaseless play of cilia on the animal's body, these currents acting not so much by their force, as by their constant and long-continued impulse, just as the drop from the eave will in time wear a basin in the stone floor underneath. The other theory ascribes the whole works of the whole tribe to the animal itself operating on the wood or rock with an organ fit and fitted for the purpose.

The mechanical theory seems to have been suggested, in the first instance, by a false view of the valves of the Teredo, which their form misled the earlier naturalists to believe were the teeth of the animal, and that with them the animal eat its way into the wood.* When this mistake of office was discovered, the organs were construed to be augers; and the other boring mollusks, it was affirmed, had organs adapted for a similar purpose either in the spinous processes or in harder and thicker margins in front, or, as in the instance of the Lithodomus, in the shape of the shell itself, which needed only to be put into a rotatory and forward motion by the muscular efforts of the mollusk. The fact of there being such a rotation of the shell was deemed to be proved by the circular striæ which some naturalists had observed on the walls of the cells of our common Pholades.

The chemists, on their part, were driven to a hypothetical acid by the many objections which seemed to render any mechanical explanation untenable. There was no proportion between the creature's physical powers and the results produced; the substance operated upon was, in many cases, harder than the shell, and more likely to wear away its processes and asperities than itself to be perforated; and yet the shell remained intact, and there were no appearances on its parts or surface to indicate that it had been used either as a rasping or boring instrument, the very skin covering the valves remaining uninjured. It was even said, that the form and size of the cell made a rotatory motion of the animal in it impossible, as surely was the case

* Home's Comp. Anat. i. 377. Delle Chiaie defines the Teredo—"Animal—anterius maxillis lignum terebrans."—*Anim. Nap. s. Vert.* iv. 32.

with the Teredo. These objections appearing insurmountable, a solvent acid was called in to explain the facts, and when the acid was named, it was said to be the phosphoric; until Dr. Drummond suggested that the mollusks might decompose the sea-salt, as their wants required, and apply the liberated muriatic acid to the solution of the calcareous rock.* The existence of the solvent was at first taken for granted, but when a stricter examination called for the proof, it was found that there was none to be detected in the animal by any test. And so another supposition was made, that the acid was secreted only when wanted; and, to obviate the objection that this solvent liquor might rather dissolve the shell than the rock and timber, we were told that the animal had the power and organs to apply it only where its instinct taught it that it could be applied to the proper purpose. Another objection, that a solvent which could soften limestone and shale, siliceous grit, and clay, and wood of every kind, and even wax (for a Pholas has been found buried in wax), was one only to be equalled by the universal elixir of the alchemists, was apparently left to every inquirer's own disposal.†

The question was in this unsatisfactory state, when Mr. Osler attempted its solution in an essay of great interest, printed in the "Philosophical Transactions for 1846."‡ He found reason to think that both the above theories were right, but neither of them universally applicable. The anatomical structure of the Pholas (Fig. 27), led him to the conclusion that it excavates its cell mechanically by employing the shell as a rasp; and the part employed in boring is the anterior or lower portion of the shell, which

* Letters to a Young Naturalist, 230.

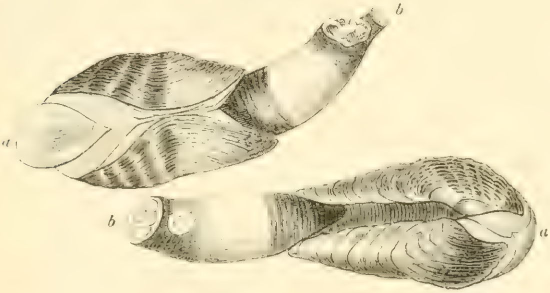
† "It has been objected that any solvent which would act on a calcareous rock would equally act on the calcareous shell of the animal; but there is, perhaps, more of point than of strength in this objection. Without laying too much stress on that law of nature by which chemical and vital forces are placed in a state of hostility, and which may or may not be applicable to such a substance as shell, the gland for the secretion of the supposed solvent, as well as the organ for applying it, may be so placed as that the solvent shall only come in contact with the inorganic or dead substance to be acted on, without touching the shell.

"Again, it has been asked, what solvent would act equally on a calcareous and on a siliceous substance? To this it may be answered, first, that it is not pretended that the nature of the supposed solvent is known; secondly, that in siliceous grits there is more or less calcareous matter by which the mass is held together, and that the solution of the calcareous particles would be followed by the disintegration of the stone."—Broderip in *Trans. Zool. Soc. Lond.* i. 266.

‡ Part iii. 342. "On Burrowing and Boring Marine Animals," by Edward Osler, Esq.

is thicker and armed with much stronger spines than any other part. After a minute account of the peculiar muscles by which, with the assistance of the foot, the shell is worked, Mr. Osler goes on to say,—"The Pholas, then, has two methods of boring. In the first, it fixes itself by the foot (*a*, Fig. 27), and raises itself almost perpendicularly, thus pressing the operative part of the shell upon the substance to which it adheres. It now proceeds to execute a succession of partial rotatory motions, effected by the alternate contraction of the lateral muscles, employing one valve only, by turning on its side and immediately regaining the erect position. This method is almost exclusively employed by the very young animals, and it certainly is particularly well adapted for penetrating in a direction nearly perpendicular, so that

Fig. 27.



they may be completely buried in the shortest possible time; a time still farther diminished by their form: for at this early age the posterior extremities of the valves are much less produced than they afterwards become.

"But when the Pholades have exceeded two, or at the utmost, three lines in length, they change the direction and work horizontally; for the altered figure of the shell, and the increased weight of that part of the animal behind the hinge, prevent them rising so perpendicularly as at first. In the motions required to enlarge the habitation, the adductors perform a very essential part. The animal being attached by the foot, brings the anterior points of the shell into contact. The lateral muscles now contract, and raising the posterior extremity of the shell, press its operative part against the bottom of the hole, and, the moment after, the action of the posterior adductor brings the dorsal margins of the valves into contact; so that the strong rasp-like

portions are suddenly separated, and scrape rapidly and forcibly over the substance on which they press. As soon as this is effected, the posterior extremity sinks, and the stroke is immediately repeated by the successive contractions of the anterior adductor, the lateral, and the posterior adductor muscles."

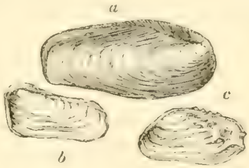
Thus do these creatures mine their cells; the instinct which directs them operating from their earliest infancy; for they are found completely buried, when so minute as to be almost invisible; and the rapidity of their growth, for the first few weeks, compels them to exert themselves perseveringly in effecting the enlargement of their habitation. The particles of clay or wood worn down by their operations, and which, in a short time, completely clog the shell, are removed in a very simple manner. The animal fills the siphonal tubes (Fig. 27, *b*), which convey water into its body, closes the orifices and retracts them suddenly; by which act the water which they contained is ejected forcibly from the opening in the mantle; and the jet is prolonged by the gradual closure of the valves, expelling the water contained within the shell. The chamber occupied by the animal is thus completely cleansed; but as many of the particles washed out of it will be deposited before they reach the mouth of the hole, the passage along which the Pholas projects its siphon, is constantly found to be lined with a soft mud.

The Teredo, according to Mr. Osler, is also a mechanical borer, and it does its work much in the same manner, and by means of a structure very analogous to that of the Pholas. The muscles, indeed, vary in their relative size, because their size is proportioned to the force they are required to exert, which differs in the two genera; but their arrangement and mode of action are so similar, that it is unnecessary to enter into the detail. The Teredines, it would seem, however, do not eject as useless all the débris worn down in their operations, but turn part of it, at least, to their nourishment, for Mr. Hatchett found the contents of the intestine to be "vegetable sawdust." It is also worth remarking, that they bore in the direction of the grain, whether the wood be erect or otherwise; and they work across the grain of the wood as seldom as possible; for after they have penetrated a little way, they turn and continue with the grain tolerably straight until they meet with another shell, or perhaps a knot, which produces a flexure, the course and size of which depend on the nature of the obstruction, and which, if considerable, causes the indivi-

dual to take a short turn back in form of a siphon, rather than work any distance across the grain.

But the Lithophaga and Lithodomi (Fig. 26 *a*) have no organs for boring similar to those in the Pholas, and yet it were reasonable to suppose for them a structure stronger and more fully developed for the purpose, did they really operate mechanically, seeing that the substances they dig into are harder than those selected by the Pholas or Teredo. This anatomical argument might be deemed sufficient of itself to prove that the Lithophaga must work by the agency of other means. Moreover, the texture of the shell is so soft, that it could make no impression upon the stone without being itself acted on; and the effect of this would be permanent, because superficial injuries of the shell are never repaired. But nothing of this kind is met with. Mr. Osler has even found a Saxicava rugosa (Fig. 28, *a*), the species on which his observations were made fixed between two others, which was so compressed that it was quite flat, and little more than a third of its proper thickness; yet neither of the three showed the slightest mark of friction, and the cuticle of the sides in contact was as perfect as usual.

Fig. 28.



What, then, is the power which the Saxicava and its congeners employ? The question, Mr. Osler admits, has not been perfectly resolved: but it is probably an acid excreted by the animals, capable of softening or dissolving lime. An objection to this may be taken from some facts already mentioned, viz., that these shellfish are sometimes found in argillaceous as well as in calcareous rocks. The facts, however, admit of explanation; for the young animals may be supposed to fix themselves in holes or crevices convenient for their purpose, and which afford them immediate shelter. Hence they are occasionally found lodged among the entangled roots of sea-weed; and they will sometimes find a shelter in rocks upon which they are unable to act chemically. And that this explanation is correct may be proved by the examination of the cells, which are not smoothed and fashioned to the shape, as they are when excavated in limestone: and, indeed, when burrowing in the latter, if the animal meets with a piece of clay or feldspar, its progress is immediately stopped, or the shape of the shell is deformed by the pressure of this insoluble substance. The cells in the pillars of the temple of Jupiter Serapis afford examples of

this fact, and Mr. Osler has adduced several others which fell under his own notice.

To answer the objection that this solvent of limestone must act destructively on the shell itself, which is of the same composition, and certainly not more insoluble than the rock, Mr. Osler supposes that the animal has the power of applying its solvent to a limited space external to the shell, where it is quickly neutralized and rendered harmless. The instrument of the application he believes to be the foot, an organ which admits of being extended to a length fully equal to that of the shell, and appears to be perforated by a tube, which passes forward from the part where it joins the body and terminates abruptly on the under surface near its extremity. By this instrument the liquid can be applied remote from the shell, which is thus removed from its destructive influence. Where the Saxicavæ are numerous, their holes communicate very freely; and it is common to meet with one which has attached its byssus to another. In this case, it is always found that the shell of the second has been acted on in a direction, and to an extent, which corresponds with the range of the foot of the assailant. The neighbouring shells are very often thus corroded. "On examining a considerable number," says Mr. Osler, "taken indiscriminately from the same rock, I have found that the shells of more than half had been thus injured. As long as the injury is superficial, no attempt is made to repair it; but, when the shell is nearly or quite penetrated, the breach becomes filled, not with new shell, but with a firm yellow substance, which is insoluble even in a strong mineral acid. It would be difficult to conceive a fact, short of absolute demonstration, which could give a more decisive support to the theory of a solvent. A peculiar provision is given to the animal to preserve it from destruction by an injury to which it is particularly exposed. The supposition of mechanical penetration would require us to believe that a newly formed substance, much softer than that which has been destroyed, can stop the progress of the mischief, and even repair it, under the continued application of the original destructive force."

These arguments seem good, yet a solvent has never been detected; and every experiment which Mr. Osler made for this purpose was quite unsuccessful. Had the question been previously balanced, the inability to detect a solvent would justify strong doubts of its existence: but, while all the facts connected with the natural history of the Lithophaga afford consistent support to the theory of a solvent, and are opposed to the supposition of penetration by a mechanical

force, the failure of the experiment cannot be considered to militate very strongly against the only inference to be drawn from the facts. And it may be observed that, where the Lithophaga happen to be lodged in situations which afford them sufficient room and shelter, they make no attempt to enlarge their habitation. Thus Saxicava præcisa (Fig. 28 *b*) is more frequently found among groups of Serpulæ, or in the roots of sea-weed, than in a hole excavated by its own efforts; and Mr. Osler has obtained full-grown specimens of Saxicava arctica (Fig. 28, *c*), attached by the byssus to a Pecten. It may therefore be presumed that the solvent is secreted only when its agency is required; and this would sufficiently explain why a free acid cannot be detected in the animal by any chemical tests.

The views of Mr. Osler were eagerly adopted by British naturalists, at least, and they remained unchallenged for several years, perhaps from an unwillingness to re-agitate and unsettle a question that had long fretted the inquirer by its uncertain and debatable character.* Mr. Garner, without any formal attempt to expugn them, preferred a very different explanation; for, availing himself of the modern discovery of the existence of vibratile cilia on many of the surfaces of animals, he almost assumed that the currents of water produced by the cilia of the mollusca in question were sufficient to work out their excavations.† The insufficiency of this cause seemed always to me almost self-apparent, and that it is so has been amply proved by Mr. A. Hancock; who has, with no little ability, shown the equal invalidity and erroneousness of all previous explanations. He reviews, in an interesting manner, the arguments and facts which have been adduced to prove that the Teredo bores in the manner of an auger, and he finds ample proof of the contrary in the shape and habits of the animal: he shows us that the Pholas has not the amount of rotatory

* "And, indeed, this is an error, which is very natural to men's minds: they love not a long and a tedious doubting, though it brings them at last to a real certainty; but they choose rather to conclude presently, than to be long in suspense, though to better purpose."—SPRAT'S *Hist. Roy. Soc.* 32.

† "It appears, then, that the mechanical apparatus of the different boring animals of this class is insufficient to account for their power of excavation; and we must attribute it principally to the action of the ciliated foot and tentacles causing a never-ceasing vortex at the inferior extremity of the cell. In some of these animals, too, the body is much produced, having the tube of its mantle garnished with its continuous branchiæ, the cilia of which must give great force to the rushing column of water. If any species make use of its valves as adjutory, it would be the Teredo, which attacks the hard planks of ships."—GARNER in *Charlesw. Mag. N. Hist.* iii. 300, 301.

motion ascribed to it; that the shell cannot, by any amount of this action, form the cell of the figure it really has; that the armature and natural coating of the shell, as also the coating of soil often found on it, are adverse to the mechanical theory; and that the operations of the very young, and the shape and proportion of the cell in the adult, are equally contradictory of it. In a similar manner Mr. Hancock reviews the chemical theory, to which the great objection has ever been the non-existence of any acid in the organs of the animals that could be employed in secreting it or applying it. Mr. Hancock has not only been unable to discover any acid, but his ingenious and patient experiments demonstrate that there is none to discover. After having determined, he says, beyond a doubt, that the anterior portion of the animal is the boring instrument; "and presuming, if an acid existed, that it would be secreted by follicles in the skin of this part, I removed it from the living animal, and placing the part so removed on litmus paper, pressed it gently between two pieces of glass, so as to force the fluids out of it. This experiment I have frequently repeated, but never succeeded in detecting an acid. Another method was also adopted for this purpose. Several specimens of various growths were taken from burrows, and placed in a vessel of fresh sea-water with the anterior portion of the animal in contact with litmus paper. Here they remained for upwards of a week: three or four attached themselves by their byssus to the test-paper, and continued so with the excavating portion of the animal resting upon it for several days; but the result was again negative—not the slightest stain was apparent."

The original theory* of Mr. A. Hancock well explains all the phenomena of the question, and the structure on which it mainly rests is found in all boring mollusca. Of the acephalous kinds which bore in wood and in various

* Ann. and Mag. Nat. Hist. xv. 114. Feb. 1845. Messrs. Forbes and Hanley have made some objections to Mr. Hancock's discovery, which, I think, further research will prove to be ill founded. The reader will find in their work, a very interesting sketch of the history of opinions in regard to the boring faculty of these mollusca, and some facts derived from sources to which I have not access. They are of opinion that the mollusks excavate their cells principally by a rotatory motion of the shell, produced by appropriate muscles, and aided by currents of water set in motion by cilia. The discovery of a peculiar structure of the shell of boring mollusks, by M. Necker, viz., that "these shells are composed of arragonite," removes a difficulty, since now "there is no reason for supposing that the shell of the Pholadidæ is so weak a perforating instrument as some have fancied." —*Brit. Mollusca*, i. 96—107.

clays and rocks, or shells, he finds that the excavating instrument is the anterior portion of the animal, either the foot and the edges of the mantle, or the edges of the mantle solely. These organs are fitted for the office they are to perform not only by their position and figure, and their pliability and muscular structure—made more than commonly muscular for the duty,—but also by being armed with a rough layer of numerous crystalline particles of various sizes and shapes, chiefly five and six-sided, and all having one or more elevated points near the centre. These crystals are imbedded in the surface of the boring-foot and thickened edges of the mantle; and, consisting, probably, of silex or flint, either pure or in combination with some animal matter, they form a sort of file,—superior, however, to any of our workmen's files in this, that the surface keeps itself always in a proper state of roughness for trituration. This is done by an organic law, which causes the crystals to be constantly shed and as constantly renewed, just in the same manner as the epithelial scales are on the surfaces of all exposed animal membranes.

There is in this theory, a simplicity and adequateness, that seem to mark the invention as one from above; and it strongly recommends itself to our common sense. I must refer you to the author's essay* for the more ample proof of it, but I cannot refrain quoting some passages for your immediate perusal.

"The foot and mantle of Teredo, Pholas and Patella, and the thickened portion of the mantle of Saxicava, Gastrochæna and their allies, appear, then, to be rubbing disks of extraordinary power, crowded as they are with these siliceous bodies, which penetrating the surface give to it much the character of rasping or glass-paper. And all that now remains to be proved is the existence of muscles to give to this formidable cutting surface the necessary rubbing motion.

"These muscles are amply provided; the adhesive portion of the foot, as well as the mantle, of Teredo and Pholas, and also of Patella, are composed of interlaced muscles. The anterior thickened part of the mantle of Saxicava is also made up of muscular fibres running in all directions. And Professor Owen, in his account of Clavagella, states that, 'the muscular layer, after forming the siphon and its retractors, is confined to the anterior part of

* "On the Boring of the Mollusca into Rocks, &c.; and on the Removal of Portions of their Shells." By Albany Hancock, Esq., in *Ann. and Mag. N. Hist.* ser. 2, ii. 225. Oct. 1848.

the mantle, where it swells into a thick convex mass of interlaced and chiefly transverse muscles.' Surely this powerful muscular apparatus has some important function to perform,— not to secrete a solvent, but to assist by its mechanical agency in the work of excavation.

"We now see the boring instrument complete in all its parts; and a more efficient apparatus could not be devised. Supplied with this flinty armature, the soft fleshy foot of Pholas and Teredo, adhering to the substance to be reduced, and aided by the edges of the mantle, cuts with equal facility into wood, shale, chalk, and the various other bodies into which these mollusks burrow. Patella excavates in the same way. The mode is somewhat varied in Gastrochæna and Saxicava; they firmly attach themselves by the byssus to the rock, then bring into contact with it the armed and thickened portion of the mantle, thus enabling the interlaced muscles of which it is composed to work with as much effect as those in the broad adhesive foot and mantle of Pholas and Teredo.

"In none of these species is much rotatory motion required. In Pholas and Teredo, little more than the mere contraction of the cutting-surface is sufficient; each portion of the foot and mantle, which together nearly fill up the bottom of the excavation, acting immediately on the substance with which it is in contact. The same thing takes place in Patella, which evidently does not rotate, for the burrows are elliptical, like the animal, and fit with great accuracy the marginal indentures of the shell. But the cutting disk of Saxicava and Gastrochæna being narrower than the burrows, these species must, at intervals, move a little from side to side, anchoring themselves afresh by the byssus whenever they shift their position. In all, however, the same vermicular contraction of the parts, observed by Sir Everard Home in the foot or 'proboscis' of Teredo, will be required to remove the substances into which these animals bore.

"Thus this perplexing subject is simplified; and judging from analogy, there can be little doubt that all the boring mollusks excavate in the same manner: none by the rasping or cutting of their valves,—none by a solvent,—none by ciliary currents. We should, therefore, be inclined to doubt that any of the Acephala bore, which are not provided with either the broad adhesive foot, or with the thickened mantle united in front. Venærupis perforans may be, perhaps, cited as an exception to this rule; but it is doubtful whether it ever bores. On the coast of North-

umberland, where there is abundance of soft shale and a great variety of rocks, it certainly never does so: but it frequently takes up its abode in the old burrows of Pholas and Saxicava; and it is probably owing to this habit that powers have been attributed to it which it does not possess. From a similar habit, Kellia suborbicularis has also been stated to excavate; and it is not unlikely that several other reputed borers have no better title to be so considered.

"It may still be asked, If the armature be of this formidable nature, how is it that Saxicava is entirely confined to calcareous substances? Why should it not likewise burrow in softer materials, such as wood and shale? This may be answered by another question—Why do Teredo and Pholas striata always bore in wood? And why is not Saxicava itself found in shells of other mollusks, as is frequently the case with Lithodomus?—for certainly an acid solvent could dissolve the calcareous covering of these animals as well as hard limestone.

"Some impulsive instinct is most probably the guidance in these matters, leading each species to that substance best suited, in some way or other, to the economy of its life. This selection, without an apparent cause, is observed everywhere in the wide field of nature: we see it in the nests of birds, which in closely-allied species are frequently built of different materials; and we see it in a striking manner in the habits of the burrowing bees. The Carpenter-bees (Xylocopæ) are well known to excavate in wood. There is a species, however, of an allied genus, the Anthophora retusa, which 'makes its nest, not only in hard, dry banks, but also in the crevices of walls, burrowing through the mortar, and causing much damage by loosening the bricks.' It cannot be from want of power that this species does not penetrate wood.

"In Saxicava there is also a mechanical cause which may have something to do with the matter. It has been already stated, that the rubbing instrument is held by the attachment of the byssus in contact with the substance to be excavated; and as the byssus is small, it is ill calculated to maintain its hold of soft friable rocks, such as shale, which, on the coast of Northumberland, is frequently exceedingly brittle; so much so that the Algæ seldom grow on it, and the Patellæ rarely trust themselves to its treacherous surface. Clavagella, however, appears to burrow in soft substances as well as in hard ones. This is easily accounted for by the fact that the attachment of one of the valves to the side of the burrow renders the support of a byssus

unnecessary; and having an extensive fulcrum, this species can therefore excavate in soft substances with as much facility as Pholas." *

There are no borers amongs the tunicated, brachiopod, or cephalopod mollusca; but a few of the Gasteropods have the same power, and it has been attributed to others, on rather uncertain grounds. The Limpet (Patella vulgata) seems to be in the habit of hollowing out a space in the site on which it has settled, answering to the size and shape of the rim of the shell; and it does this probably with the intention of obtaining a stronger seat or hold with the expenditure of less muscular power, or rather, with the relaxation of all muscular contraction, so that the shell may be elevated sufficiently to admit the influx of water around the branchiæ without any danger of the animal being driven from its settlement. The excavation varies in depth, not according to the chemical composition, but according to the softness of the site,—from a line to half an inch; but the shell is never buried in it. Mr. J. E. Gray, who first called particular attention to this peculiarity in the limpet's habits, explained the operation as the result of a solvent fluid, excreted from the sole of the foot, of which, however, no evidence was produced. De Montfort came near the truth. Some Patellæ, he says, when in a state of repose have a peristaltic motion in the foot, which slowly hollows out the stone on which they rest by friction alone, and these species are sedentary.† "By friction alone" the operation is done, and the foot is armed with hard crystalline siliceous spicula, similar in all respects to those of the perforating instrument of the Pholas, and replaced by new ones as often as the friction has rubbed off the asperities of the old.

The questionable Gasteropod borers are our common snails. I shall give you all the evidence I possess, and, curiously enough, the question has become connected with some interesting geological phenomena, which lie, however, beyond our demesne.—"On the east side of Whelpington," says the Rev. Mr. Hodgson, in his "History of Northumberland," "a stratum of limestone is here and there seen in grey projecting masses, the under-surface of which is bored upwards into cylindrical holes, which are from a line to four inches deep, and tenanted, especially in winter, by the banded and yellow varieties of the Helix nemoralis. The Limax, while it occupies these cavities during the summer, has its fleshy

* Ann. and Mag. N. Hist. ser. 2, ii. 242—244.

† Conch. Syst. ii. 68.

longitudinal disk protruded out of the shell, and coiled nearly into a circle on the surface of the stone, the summit of its shell hanging downwards; and in this position it probably elaborates its den in the same manner that some of the Pholades work their way into clay and wood, or, by a slow but constant process, sink and enlarge their cells in the hardest stones." * In the subsequent page, the Reverend annalist attributes the same property to Helix (Limnæus) putris, and makes it the agent of holes in the bed of the little river Wansbeck. The proof, you will observe, here led for the Helices being the operators is very inconclusive; and I shall leave the following, made by a more scientific observer, to your own judgment:—"During the meeting of the Geological Society of France, at Boulogne, in September, 1839, Dr. Buckland's attention was called by Mr. Greenough to a congeries of peculiar hollows on the under-surface of a ledge of carboniferous limestone rocks. They resembled, at first sight, the excavations made by Pholades, but as he found in them a large number of the shells of Helix aspersa, he inferred that the cavities had been formed by snails, and that probably many generations had contributed to produce them.

"A few years since (viz., previous to 1841), the Rev. N. Stapleton informed the author that he had discovered at Tenby, in the carboniferous limestone on which the ruins of the castle stand, perforations of Pholades thirty or forty feet above high-water level; but having recently examined the spot, Dr. Buckland ascertained that these excavations were the work of the same species of Helix as that which had formed the cavities in the limestone near Boulogne, and he found within them specimens of the dead shells as well as of the living. The mode of operation by which the excavations were made, he conceives, is the same as that by which the Common Limpet (Patella vulgata) corrodes a socket in calcareous rocks, and he is of opinion that the corrosion is due to the action of some acid secreted from the body of the limpet or helix." A little afterwards the celebrated professor observes, that the snails "could find shelter only on the margin and lower surface of the projecting rock, and the irregular form of the confluent cavities correspond with that of the clusters of snails in their ordinary habitat and hybernation; and if to those reasons be added, the fact of finding both living and dead shells in the excavations, the evidence, the author conceives, is decisive as to the agency of snails in

* Hist. North. part ii. vol. i. 193.

producing the phenomena under consideration." * I beg to put in a demurrer to this conclusion, until more decisive proof is given me in the detection of an organ fitted to make the snail a boring operative.

A very few mollusks not endowed with the mechanical power to bore and tunnel, and yet, as it were, conscious that some extraneous covering would be useful to them, set about to provide it each after its fashion. Thus the Phorus, which is a genus of nomade Gasteropods, gathers together the dead and living shells of other species, and intermingling them with pieces of broken coral and small stones, glues them to the outside of its shell so as to hide its true features and make it pass as a dead mass of inorganic matter; or, as when the cemented shells are of the turreted kind, it may frighten thus away an enemy, for the shells, pointing in all directions, present to view an armature of strong spikes, on which even a hungry fish might hesitate to feed. Some Modiolæ cover themselves with a hairy vestment made of the threads of their byssus;† and one native Crenella (C. discors), "forms for itself a kind of nest or case by stitching together the small sea-weeds or corallines with its byssal threads;" ‡ while another (C. marmorata) digs deep into the leathery coat of Ascidia, and very effectively hides itself there. The unmoving Gastrochæna modiolina is found on the Guernsey shores, living in the crevices of rocks amidst the débris of madrepores, and of shells and gravel; and with this material it puts together a sort of nest or chamber that resembles a Florence flask, and completely encases the shell. The outside of the nest is rough, but the inside is smooth, and consists of thin layers of a calcareous secretion applied by the animal, which leaves open the neck of the nest whence it protrudes the tubes of respiration and of effete matters. The animal can, of course, enlarge the nest to suit its growth, and it can also prolong the neck so as to keep it above any overlying madrepores. § The Lima, whose active habits I have had already occasion to notice, is also occasionally a nest-

* Ann. and Mag. N. Hist. viii. 459.

† Philippi thus describes the nest of his Modiola vestita: "Involucrum mirabile sacci instar totam testam occultans, intus e tomento filorum cinereorum, extus e lapillis, conchyliorum fragmentis et similibus compositum est, et cum parte postica cohæret, a cujus filis ex parte ortum videtur. Byssum nullum inveni, cumque fugacem, a filis tenuissimis contextum fuisse saccoque forte altera ex parte originem dedisse puto."—*Mollusc. Sicil.* ii. 51.

‡ Alder in Trans. Tynes. Nat. Club, i. 175.

§ Loudon's Mag. N. Hist., vi. 404. All Gastrochænæ make similar bottle-shaped cases. See Forbes and Hanley's Brit. Mollusca, i. 133.

builder; and I must not injure the interest of the following account of it by any curtailment. With a party of friends the Rev. David Landsborough dredged Lamlash Bay, on the 4th of June, 1846, and he says:—"The most interesting, though not the rarest thing we got, was Lima hyans of continental writers, Lima tenera of Turton. I had before this some specimens of this pretty bivalve, and I had admired the beauty and elegance of the shell, but hitherto I had been unacquainted with the life and manners of its inhabitant. Mr. and Miss Alder had got it in the same kind of coral at Rothesay, so that when Miss Alder got a cluster of the coral cohering in a mass, she said, "O, here is the Lima's nest!" and breaking it up, the Lima was found snug in the middle of it. The coral nest is curiously constructed, and remarkably well fitted to be a safe residence for this beautiful animal. The fragile shell does not nearly cover the mollusk—the most delicate part of it, a beautiful orange fringe-work, being altogether outside of the shell. Had it no extra protection the half-exposed animal would be a tempting mouthful—quite a bonne-bouche to some prowling haddock or whiting; but He who tempers the wind to the shorn lamb, teaches this little creature, which he has so elegantly formed, curious arts of self-preservation. It is not contented with hiding itself among the loose coral, for the first rude wave might lay it naked and bare. It becomes a marine-mason, and builds a house or nest. It chooses to dwell in a coral grotto. But in constructing this grotto it shows that it is not only a mason but a rope-spinner, and a tapestry-weaver, and a plasterer. Were it merely a mason it would be no easy matter to cause the polymorphous coral to cohere. Cordage, then, is necessary to bind together the angular fragments of the coral, and this cordage it spins; but it spins it as one of the secrets of the deep. Somehow or another, though it has no hand, it contrives to intertwine this yarn which it has formed among the numerous bits of coral so as firmly to bind a handful of it together. Externally, this habitation is rough, and therefore better fitted to elude or to ward off enemies; but though rough externally, within all is smooth and lubricous, for the fine yarn is woven into a lining of tapestry, and the interstices are filled up with fine slime, so that it is smooth as plasterwork, not unlike the patent Intonaco of my excellent, ingenious friend, Mrs. Marshall. Not being intended, however, like her valuable composition, to keep out damp or to bid defiance to fire, while the intertwining cordage keeps the coral walls together, the fine tapestry mixed with smooth and

moist plaster, hides all asperities, so that there is nothing to injure the delicate appendages of the enclosed animal. Tapestry, as a covering for walls, was once the proud and costly ornament of royal apartments; but ancient though the art was, I shall answer for it that our little marine artisan took no hint from the Gobelins, nor from the workmen of Arras, nor from those of Athens, nor even from the earliest tapissiers of the East. I doubt not, that from the time Noah's ark rested on the mountain of Ararat, the forefathers of these beautiful little Limas have been constructing their coral cottages, and lining them with well-wrought tapestry in the peaceful bay of Lamlash.

"When the Lima is taken out of its nest, and put into a jar of sea-water, it is one of the most beautiful marine animals you can look upon. The shell is beautiful; the body of the animal within the shell is beautiful; and the orange fringe-work outside of the shell is highly ornamental. Instead of being sluggish, it swims about with great vigour. Its mode of swimming is the same as that of the scallop. It opens its valves, and suddenly shutting them, expels the water, so that it is impelled onwards or upwards; and when the impulse thus given is spent, it repeats the operation, and thus moves on by a succession of jumps. When moving through the water in this way, the reddish fringe-work is like the tail of a fiery comet. The filaments of the fringe are probably useful in catching its prey. They are very easily broken off, and it is remarkable that they seem to live for many hours after they are detached from the body, twisting themselves like so many worms."*

I shall conclude this long letter with a table, from the study of which you may be enabled to methodize the information I have endeavoured to give you relative to the locomotion of the mollusca; and it will also exhibit the analogies, which, in this view, exist between the various orders and families.

* Excursions to Arran, p. 319.

	Cephalopods.	Pteropods.	Gasteropods.	Common Bivalves.	Brachiopods.	Tunicata.
SWIMMERS	All the Decapods, *e. g.* Sepiæ, Loligines.	The entire class.	Heteropods; Pterosoma; Glaucus; Briarea.	Limæ: some Pectens; Oysters when young, and larvæ in general.		Salpæ; Pyrosoma, and all in the egg and larva state.
CRAWLERS	Octopods; Nautilus.		Inferobranches; Pulmonifera, *e.g.* the Snail; and nearly all the marine genera, as Periwinkles, Whelks, Rock-shells, Cowries, Ear-shells and Limpets.	The great majority of Bivalves with two adductor muscles and a bent exsertile foot.		
THAT SWIM AND CRAWL	Octopods; Argonauta; Nautilus.		The major part of the Sea Slugs (Nudibranches); Aplysiæ; Aceres; many minute littoral shells.			
BURROWERS			Testacellus; Naticæ; Cymbium, and some Buccinæ.	The majority of Bivalves; most remarkable in Solen, Mya, Mactra, Pholas, Teredo, &c.		
STATIONARIES			Vermatus; Magilus; Siliquaria; Hipponyx; Dentalium.	Ostreæ: Anomiæ; Pedum; Spondylus, and footless Bivalves.	The whole order.	Ascidia and its allies, Botryllidæ.
SPINNERS			Physa; some Rissoæ; Litiopa; Limax.	Pectens: Aviculæ; some North American Unios; Byssoarcæ; Lima; Mytilidæ; Pinna; Byssomia; Kelliadæ; Saxicavæ; Aspergillum.		

LETTER XI.

THEIR SYSTEM OF AQUEDUCTS.

I HAVE often been struck, when examining the testaceous mollusca, with the great difference between the size of the animal when fully extruded and when contracted within the chambers of its shell. It may not be compared to that power of expansion and contraction which Milton assigns to the fallen spirits when they thronged the council-hall of Pandemonium,—who

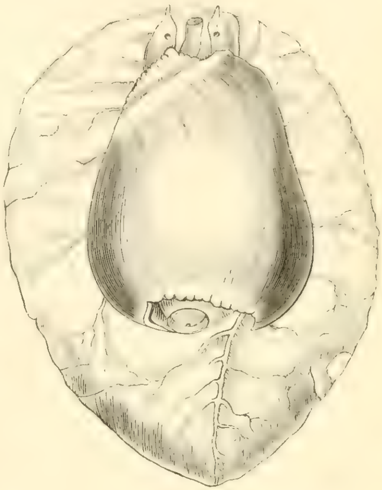
> " To smallest forms
> " Reduced their shapes immense ;"

but it is so remarkable that, when once observed, it can scarcely fail to raise a question of its cause and end. You may observe the difference in almost every marine mollusk, though we have no species on our shores that exhibits it in that excess of which we have an example in the " Yet " of Adanson, (Cymba neptuni, Sow.,) where the protruded foot far exceeds the entire bulk of the shell (Fig. 29). The Cowries and the Tun-shells (Dolium) are examples of the same excess, and in the former the breadth of the foot, and the extent of the mantle-lobes, contrast strongly with the narrowness of the shell's aperture.* Nor is the fact less visible in the land tribes, for just recall to memory the size and figure of the common snail as it crawls along, and you will then admit it to be curious how such a broad elongated foot, and all the tentacula, can be so nicely compacted together as to be contained in the shell with ease, and with room enough to spare. I have already called your attention to

* Of Buccinum lævigatum, and B. achatenum, Mr. Swainson says,—" Both these have the foot of an immense size, so that it spreads over a circumference near three times as large as the shell, and is sufficient to envelope it entirely."—*Malacology*, 74. The genera of Gasteropods, which have the foot disproportionably large, are Dolium, Oliva, Ancillaria, Bulliana, Harpa, Voluta, Cymbium, Ovula, Cypræa, and Natica and Bulla. An orifice for the introduction of water within the foot is seen also in Conus and Nassa, where the foot is comparatively small. See " Figures of Molluscous Animals," etched by Maria-Emma Gray, vol. i. Lond. 1842 : one of the most valuable works which the conchologist can place in his library.

the same phenomena as exhibited in the bivalved mollusca, in whom the foot can frequently be made to surpass the shell; nor is this capacity of temporary and varying increase in size limited to conchiferous mollusks, but is possessed also by the naked species. The slugs are more tumid and transparent in moist weather than in a drought; and the sea-slugs, whether Gasteropod or Pteropod, retain only their amplest dimensions when immersed in water; for when removed thence, they shrink and shrivel down to perhaps a half of their former bulk. This increase in any species is always accompanied with a greater transparency of the body; and only in this state can the tentacula and the other exterior organs of the animal be properly displayed, or progression accomplished.

Fig. 29.



The mechanism by which the animals effect these relative changes in their bulk is curious and simple. Were you to fill a cup exactly with a dried sponge, you could make it rise above the rim, and expand over it on all sides by pouring some water into the cup. The water does not float the sponge, but is imbibed into its interior by percolating through its pores and canals. It is somewhat similar with some of the mollusca. These are framed with a system of canals and cavities, excavated principally in the foot and penetrating it thoroughly, which has a communication with the exterior surface on the one hand, and leads into the visceral cavity on the other. The circumfluent water entering by the external orifices flows into and through these canals, fills them and the cavities with which they communicate, and, as a necessary sequence, the organs are distended, enlarged, and rendered firm and more capable of muscular exertions. When the animal wills to come out from its shell, or to remove to another site, the water is made to flow inwards through the aqueducts; and when it wishes to reenter or conceal itself, the muscular compres-

sion of the parts forces the water again from the body by the same channels.

The discovery of this remarkable system of aqueducts was made by the Neapolitan naturalist, S. Delle Chiaie, not more than thirty years ago.* He detected it in many testaceous and naked Gasteropods; and ascertained that there were no traces of it in some freshwater genera, as in Limnæus and Planorbis,—a singular exception, for which probably you may find a reason in the comparative lightness of their shells, requiring for their support no mechanical additions to their inherent muscular powers. Delle Chiaie found similar aqueducts in the arms of various Cephalopods, in whom they serve to elongate their motive organs, and to distend their acetabula previous to their being fixed upon a surface; and the muscular fins of the Pteropods are permeated by analogous canals. The discovery has been since confirmed; and the same apparatus has been shown to exist in the Bivalves by Professor Baer, of Königsberg;† in many Ascidians by Delle Chiaie;‡ and perhaps also in the pulmonated terrestrious Gasteropods by M. Kleaberg, for this seems to be the function of what he calls their "mucous ducts."§ It may, indeed, appear absurd to ascribe the office

* Anim. s. Vert. Nap. ii. 259, &c.

† The foot of Lucina "is frequently twice as long as the diameter of the animal. When not contracted, it is much longer. It is remarkable that it is hollow throughout its entire length, and that this tube opens directly and widely into the spaces of the visceral cavity."—Forbes *and* Hanley's *Brit. Moll.* ii. 42.

‡ The curiously ciliated arms of the Brachiopoda are extended by the same means. When treating of Terebratula psittacea, Professor Owen says: "The mechanism by which the arms are extended, is simple and beautiful. The stems are hollow from one end to the other, and are filled with fluid, which, being acted upon by the spirally disposed muscles composing the parietes of the canal, is forcibly injected towards the extremity of the arm, which is thus unfolded and protruded outwards."—*Trans. Zool. Soc.* i. 150. See also, p. 155, where the Professor states that in Orbicula these canals have no connection with the vascular system.

§ "In the gasteropodous mollusca of the genera Limax, Arion, Helix, and Bulimus, we find under the mouth, between the two inferior lips, and the protuberance of the disk of the foot, the orifice of a canal, hitherto unobserved, which runs along the whole of the foot. This anatomical arrangement is not very distinct in the genus Succinea, which approaches nearer to the Lymnææ in internal structure. In the Arion empiricorum, which is entirely black, we perceive a trace of this canal, which appears in the form of a whitish band. The canal is not simple; it receives many little ducts, which come from the muscular sac in which the viscera are contained. In the Bulimus ovatus, Brug., a little gland, which has not been described, opens into this canal; it is of the size of a bean, trilobate, granulated, and situated under the œsophagus and the inferior ganglion of the cerebral ring, so that it is surrounded by nervous filaments passing from this ganglion. The distribution

of aqueducts to any vessels of a terrestrious animal; but before you reject the conclusion, you will consider that this tribe is active only in a moist atmosphere, when too they swell out, and by their greater lubricity and clearness show that the body is saturated and distended with a liquid. I believe that they have absorbed this liquid from the air that surrounds them,—the moisture, however, very probably having entered through invisible pores in the skin into the loose textures and very bloodvessels of the animal.* After a long continuance of dry weather the land mollusca become extenuated; and retiring far within the shell, or under cover, they lie exhausted and incapable of any active exertion.

This apparatus for absorbing and containing water is distinguished from the circulating, and from every other system of vessels by having always an outward communication with the circumfluent fluid; but the position of the external orifices is less uniform than might have been anticipated. In some Gasteropods (Cypræa), there is a long slit in the sole of the foot near its middle; in orders (Haliotis) there are two or three pores at each extremity; in others (Doris, Aplysia, Bulla, &c.) there are a series of orifices placed round its edges. Delle Chiaie says, that where these pores exist they are passages of admission to the water; but in a large proportion of the class the surface of the foot is imperforate, and in many of these (Turbo, Trochus, Murex,† Purpuriferæ, &c.) the water enters by a peculiar orifice placed in

of all the ducts may be easily observed when filled with mercury: M. Kleaberg names them mucous ducts, but he has not been able to determine their use and importance."—*Edinb. Journ. Nat. and Geogr. Science*, ii. 63.

* "Spallanzani found that snails absorb an abundance of water, for their weight increases rapidly when they are placed in it. Jacobson has lately made experiments on the absorbing power of the Vine-snail (Helix pomatia). A solution of prussiate of potass, which was poured on the surface of animals belonging to this species, was absorbed with rapidity and passed into the mass of the blood. The blood can take up such a quantity as afterwards to acquire a deep blue colour, when sulphate of iron is added."—TIEDEMAN's *Comp. Physiology*, 90.

† In the anterior part of the foot of the Muricidæ, there are to be seen certain holes or antra, which are the apertures to as many little cavities lying underneath, and which permeate the interior substance of the foot. There are, besides, between these cavities, certain slender canals trending to the same holes or antra, by means of which the whole are connected and inosculated together. The water then entering by the syphuncle at the will of the animal, is sent upon the inferior surface of the foot, into its substance and into the antra; and flowing thence into the cavities, the foot is rendered turgid and firm; but when necessary the water, by a strong pressure, is made to transude from the substance of the foot, or is spontaneously ejected when life becomes feeble: the foot becomes then flaccid and extenuate.—DELLE CHIAIE, *Anim. s. Vert. Nap.* ii. 204.

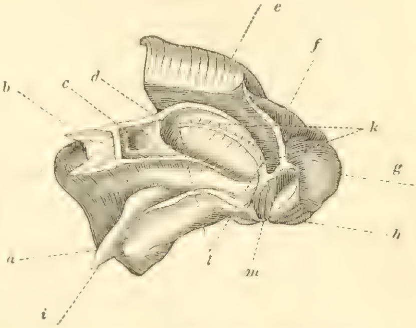
the common passage of the rectum and matrix. From this passage it finds its way through certain pores into the abdominal cavity, whence, by other appropriated channels, it flows into the canals that ramify through the foot. In many mollusks, as in the Pteropods and several Gasteropods (Tethys), no external conduits have been discovered; and in them we must believe that the water has entered within the body by transudation through the skin.

To give you a still more distinct idea of this apparatus, I will quote for you the description which Mr. Ostler has given of it in the Buccinum undatum, one of our commonest species, and which has the power of distending the foot to a size nearly, if not quite, equal to that of the shell. "A section of the foot shows it to be divided into two nearly equal parts,—the powerful muscle which extends from the operculum to the spire forming the upper or posterior half, and a cellular spongy mass constituting the remainder. The lower surface of this portion is the disk on which the animal crawls; and, being considerably longer than the muscle, it is folded upon itself, when retracted within the shell; and the operculum lies flat above it, when it is projected and extended. A transverse section of the foot, near the part where it joins the body, shows four considerable tubes penetrating the spongy portion, and very near each other; three of which are in a line parallel to, and almost in contact with, the muscle; the fourth a little below the middle one of the three. By a series of transverse sections of the foot, parallel to the operculum we are enabled to trace these tubes; and to ascertain that they become rapidly smaller as they advance until they are quite lost; the longest of them not admitting of being traced quite to the operculum. All these tubes are given off at the extreme anterior point of the thorax from a considerable one (Fig. 30), * which, being situated under the muscular floor of this cavity, takes a direction to the right side, and running just within the organs of the

* "The animal of Buccinum undatum; part of the spire of the branchiæ removed; the mantle turned to the right side; the upper part of the thorax cut away to expose its cavity, from which the boring trunk and salivary glands have been taken. *a a*, The foot; *b*, the head; *c*, a kind of platform raised above the floor of the thoracic cavity, on which the point of the boring trunk rests, and which leads to the mouth; *d*, the cavity of the thorax; *e*, the mantle; *f*, the rectum; *g*, the stomach; *h*, the heart, thrown below and to the right side of its natural situation, to allow the opening of the tube to be seen; *i*, the respiratory trunk; *k*, the origins of the muscles of the boring trunk; *l*, the course of the tube by which the foot is supplied with water; *m*, its termination."—*Phil. Trans.* for 1826, pl. xiv. fig. 3.

muscles of the trunk (*k*), passes out of the thorax, nearly in contact with, and on the right side of, the œsophagus. It terminates nearly midway between the heart and the rectum (*m*), opening into a considerable cavity, which has the liver underneath, and the membrane enveloping the spire above it. When the animal contracts the distended foot, the water is seen to flow out between the mantle and the shell on the right side. The tube and cavity are easily inflated by a blowpipe introduced into one of the tubes of the foot."

Fig. 30.



It seems obvious enough that this apparatus must be intended, principally, in aid of the locomotion of the mollusca. Delle Chiaie does not hint at this its use, but seems to have considered it as more closely connected with their respiration and nutrition, for he introduces his essay by reminding us, that water is to the mollusca in general what air is to the land animals; and he explains the fact that the former can sustain a very long privation of food, on the supposition that life is supported by the water retained in the aqueducts, and endures only until this is consumed by absorption or evaporation.* There is no doubt that the circulating fluids brought into contact with the water in the ducts will be aerated in some degree, but the main purification of the blood is left to other structures, and the system in question must have more than a secondary office, being indeed primarily designed to give buoyancy and enlargement to the body, and a greater aptitude to the parts by whose actions it is moved. When shrunk within its shell, you might well deem any animal that could hide itself there all too small and weak to carry about a burden larger and heavier than itself, and that safety might be here advantageously exchanged for relief from so much heaviness of armour, and from such an impediment to every journey. There is in my small cabinet a fine specimen of Cassis tuber-

* Van Beneden, with whom Milne-Edwards agrees, supposes that the circumfluent water gains direct access into the blood-vessels by the medium of these passages.—*Ann. des Sc. Nat.* (1845) iii. 277.

osa, which measures fully ten inches in length, and upwards of eight in breadth; another of Strombus gigas is nearly one foot in length. The weight of the former is four pounds two ounces; that of the latter, four pounds nine ounces; yet the snail creeps under this load at apparent ease. Nor are you much surprised when you see it actually in motion, for the seeming disproportion between the contained animal and containing shell has disappeared. On issuing from its cell, like an Eastern genii freed from his exorcism, the animal has grown visibly,—has assumed a portlier size and more pedestrious figure. The body has suddenly become tumid and elastic, the skin and exterior organs stretched and displayed, the foot has grown in length and in breadth, and, with additional firmness, it has acquired at the same time the capability of being directed, bent, and modified in shape, to a considerable degree, as the surface of the road traversed may require. Thus it is with nearly all the cephalous mollusca; and by a similar disposition of aqueducts, the foot of the Bivalves is equally adapted to every act subservient to their locomotion, and more especially to the act of burrowing; for had the foot not been so framed as to permit of an enlargement superior to the size of the shell, it seems obvious that the furrow could not have been made large enough to contain the latter. The same, too, with many Gasteropods which burrow in the sand when in search of prey. The Buccina and most carnivorous mollusca have this ability, dependant on the system of aqueducts we have been describing; and you must observe, that from the manner in which the shell is attached to the body by the large retractor muscle, it so happens that this is drawn into the furrow always with the notch in the aperture uppermost, so that, when completely buried, the animal is still enabled to communicate with the water by its respiratory siphon.

LETTER XII.

ON THEIR NERVOUS SYSTEM AND SENSES.

"WHEN we are in perfect health and spirits," says Dr. Paley, "we feel in ourselves a happiness independent of any particular outward gratification whatever, and of which we can give no account. This is an enjoyment which the Deity has annexed to life, and probably constitutes, in a great measure, the happiness of infants and brutes, especially of the lower and sedentary orders of animals, as of oysters, periwinkles, and the like; for which I have sometimes been at a loss to find out amusement."* There is much of truth in these remarks of the great moralist; but, nevertheless, the enjoyments, even of the oyster, are not so few and unvaried as, on a first glance, we might deem

Fig. 31.

SOLEN SILIQUA.

they were. Among the numberless happy creatures which crowd our world, the shellfish and the still more helpless Ascidiæ play, it is true, no obtrusive part, yet neither do they mar the scene by their deprivations. The performance of every function with which their Creator has endowed them, brings with it as much pleasure and happiness as their organisation admits of: in the gentle agitation of the water

* Moral Phil. bk. i. chap. 6. "We cannot take cognisance of the actions of creatures enclosed in bivalve shells; but a distinguished philosopher was so fully convinced of the happiness enjoyed by testaceous animals, that he calls calcareous mountains filled with their remains, 'monuments of the felicity of past ages.'"—BAKEWELL'S *Geology*, p. xxx. See, also, Turner's Sac. Hist. i. 204. This view is a pleasing, and, I believe, a just one, notwithstanding Virey's contrary assertion. "Les mollusques, dit M. Virey, sont les pauvres et les affligés parmi les êtres de la création ; ils semblent solliciter la pitié des autres animaux."—CHENU *Leçons Elém.* 22.

which floats around them, in its varied temperature, in the work of capturing their prey, in the imbibition and expulsion of the fluid necessary to respiration, &c., they will find both business and amusement; and, in due season, love visits even these phlegmatic things, when "icy bosoms feel the secret fire."

Yet, doubtless, from their general inertness and hebetude, we are led to infer that the sensations and passions of the molluscans are of a cold, and low character,—an inference confirmed, perhaps, by the character of the nervous system, somewhat analogous to the sympathetic system of nerves in the higher classes. The inference, however, may be erroneous: it is more certain that their organization is unfitted for the genesis of those surprising instincts which, in insects, render the limits between them and the operations of reason or intelligence very obscure and dubious. The instincts of the mollusca seem, in fact, to be almost limited to some simple devices for self-preservation. When in danger, the Ascidiæ ejaculate with force the water contained in the great branchial cavity, and drive away their weak foes; and many of the burrowing Bivalves use the same defence, sinking at the same time deeper in their furrows. The naked Gasteropods shrink within themselves, and curtail every tentaculum and process when sudden danger comes upon them; while the shelled tribes retreat hastily within their strongholds,* excepting one or two which, like the Helico-limax lamarckii and the Naninæ, endeavour to escape by additional speed. There is indeed many degrees among them in their watchfulness and caution, for some, when touched during their walk, are only momentarily arrested, and scarcely heed the annoyance; while the majority, perhaps, are so sensitive that they retire within their security from a slight cause; and remain a long time in their concealment.† To these ordinary re-

* "*Fool.*—Can'st tell how an oyster makes his shell? *Lear.*—No. *Fool.* —Nor I neither; but I can tell why a snail has a house. *Lear.*—Why? *Fool.*—Why to put his head in; not to give it away to his daughters and leave his horns without a case."—*K. Lear*, act i. sc. v.

† Perhaps the most singular instance of instinctive action in a mollusk, is that mentioned by Lister of the Helix pomatia. "De Cochlea terrestri, Pomatia Gesneri dicta, illud singulare, ineunte Junio, vidi; scilicet in dumetis juxta Ashstead, in vicinia Epsam, ubi passim occurrunt; earum non paucas, prunorum sylvestrium arbusculas scandisse, singulasque cochleas longissimâ spinâ insedisse, qualibus istæ arbusculæ donantur, ad digitum et amplius, tanquam per medium corpus transfixâ; at cum rem accuratius examinâssem, spinam medio pede positam inveni, et sic una cum eo introductam. Atque hujus quidem rei una ea utilitas esse potuit, ad sedem sibi

sources a few mollusca add the protection which a disguise of extraneous matter may give them. Thus, a very few Ascidians invest their outer tunic with a coat of sand and gravel, and become indistinguishable from the surrounding ground.* The Gastrochæna conceals itself in a case of agglutinated gravel; and the Carrier Shells (Phoridæ) attach to the outer surface of their shell, as it enlarges in size, stones, fragments of other shells, coral, and other marine substances, whence one has been called the "Conchologist," and another the "Mineralogist." Some species have this habit only in an early stage; others retain it during the whole period of their life.†

After a somewhat similar fashion, several land-snails cover themselves with a coating of extraneous materials, adapted to the different situations in which they are found, so as to be detected with difficulty. The Pupa avena, Drap., when living on rocks, clothes itself with a slight layer of white powder; but when it descends to the ground, its white dress is exchanged for one of a yellowish or greyish earth; and, according to Draparnaud, the greater number of the Pupæ and Clausiliæ have similar habits.‡ Of the Bulimus obscurus (Fig. 32) Mr. Sheppard says, "If its abode be upon the trunk of a tree covered with lichens, then is the epidermis so constructed as to cause the shell to resemble a little knot on the bark, covered with such substances. If on a smooth tree, from whose bark issue small sessile buds, as is frequently the case, it will pass off very well for one of them; and on a dry bank, or the lower part of the body of a tree splashed with mud, its appearance will be that of a little misshapen pointed piece of dirt."§ This is an

Fig. 32.

firmandam, contra ventorum impetum; alias vero rationes nescio. Actio sane mirabilis."—*Conchyl. Bivalv. Exert. Anat. tert. auct.* p. xvii.

* Of Ascidia conchilega Brugière writes, "Its surface is rough and thinly covered with long hairs, which are not easily observed, because of a singular faculty that the animal has of making an external envelope of fragments of shells, gravel, and of the vegetable and animal remains found about it: these fragments are so attached to the body that they cannot be torn away; but it appears that the creature itself parts with them and abandons them when this is necessary to its safety."—*Encyclop. Méth.* Vers, i. 148. See, also, Kirby's *Bridgew. Treat.* i. 229.

† Gray in Syn. Brit. Mus. (1842) 64.

‡ Moll. Ter. et Fluv. de la France, 17.

§ Lin. Trans. xiv. 116. According to Mr. Jeffreys, the Pupa secale exhibits the same instinct when young. "This seems a provisional defence to the animal until the teeth of the aperture are completely formed, when it divests itself of its coat by rubbing the shell against extraneous substances; and it is one of the many and various contrivances of nature which we cannot sufficiently admire."—*Linn. Trans.* xvi. 356.

interesting passage in the history of the animal, not probatory of any superior "sagacity and intelligence" certainly, but illustrative of the care of its beneficent Creator, who has bestowed upon it the instinct to do this for a purpose of which it is itself wholly ignorant: "things reasonless thus warned by nature be." It is the same unerring and unvarying principle, — like that superior light which was aforetime believed to be granted to those individuals in whom the light of reason was extinct,— that directs the Pholades in their operations, moors the mussel to the rock, and to all others teaches them their proper devices.

I am aware that some naturalists have gone so far as to say, that the mollusca, in certain acts, appear to be guided by intelligence or forethought,* and that they are "capable of deriving some knowledge from experience." The facts just mentioned will not warrant such a conclusion, which is also, it seems to me, at variance with the character of their nervous system; and the instances usually adduced in proof of it are few, either doubtful or capable of other explanation. The Mya byssifera of Otho Fabricius, the excellent author of the "Natural History of Greenland," when exposed and uncovered, affixes itself by a byssus; but when immersed in the crevices of stones or of millepores, it uses no such precaution,† rendered unnecessary to its safety from its snugger berth. We are told that oysters, when removed from situations that are constantly covered with the sea, from want of experience, open their shells, lose their water, and die in a few days: but, when taken from similar situations, and laid down in places from which the sea occasionally retires, they feel the effect of the sun's rays, or of the cold air, or, perhaps, apprehend the attacks of enemies, and accordingly keep the valves close till the tide returns.‡ The spout-fish is still more subtile and chary. "It is remarkable," says Mr. Smellie, "that the spout-fish (Fig. 31), though it lives in salt water, abhors salt. When a

* Oken, in a characteristic passage, and worth quoting as a curious extract, says, "Circumspection and foresight appear to be the thoughts of the bivalve mollusca, and snails. Gazing upon a Snail, one believes that he finds the prophesying goddess sitting upon the tripod. What majesty is in a creeping snail, what reflection, what earnestness, what timidity, and yet at the same time what firm confidence! surely a snail is an exalted symbol of mind slumbering deeply within itself.—The old artists must have felt this signification, as in many of their representations they have introduced a snail. One can hardly think that in so doing they wished to express such common and lascivious ideas as are at present manifested openly or secretly by our daily enjoyments."—*Physiophilosophy*, Trans. publ. by Ray Society, 657.

† Faun. Groenl. 409.

‡ Bingley's Anim. Biography, iii. 564.

little salt is thrown into the hole, the animal instantly quits his habitation. But it is still more remarkable, that, if you seize the animal with your hand, and afterwards allow it to retire into its cell, you may strew as much salt upon it as you please, but the fish will never again make its appearance. If you do not handle the animal, by applying salt you may make it come to the surface as often as you incline; and fishermen often make use of this stratagem. This behaviour indicates more sentiment and recollection than one should naturally expect from a spout-fish." * I think that it indicates neither; for nothing more can be safely inferred from it than that the creature has experienced, from the rough handling, a disagreeable sensation, which continues to operate for its safety for a time; and analogous facts meet us everywhere. They are all of them purely instinctive. Intelligence and reason, forethought and memory, are connected with, and, in some way, dependent on, a nervous system and a central brain; but instinct operates without any such apparatus, and is even weakened by its high developement. Thus, the nerveless Ascidia conceals itself with extraneous matters as effectually as doth the nervous Gasteropod; and the guiles and fears of the Cephalopod do not exceed those of the inferior Solen.

The happiness of molluscous animals, then, depends on the possession of life, and on the play of its functions; and, if thence we estimate their pleasures at a low scale, we must remember that their pains and sufferings are proportionably slight. Their days pass away in an even stream of quietness: there is no anger to ruffle, no disappointments to sour them; they are amply provided by Him who careth for all, and they take no care for to-morrow; and, if it prove the precursor of evil, the evil has been unforeseen and undreaded. But many of this class of animals have additional means of enjoyment in the organs of sense with which they are furnished,

* Phil. of Nat. Hist. i. 139. See, also, Forbes and Hanley's Brit. Mollusca, i. 244. Boethius's history of the pearl-mussel is written in the same loose style, but is sufficiently amusing to be given here. "They are so sensible and quicke of hearing, that although you, standing on the braie or banke above them, doo speake never so softlie, or throw never so small a stone into the water, yet they will descrie you, and settle againe to the bottome, without returne for that time. Doubtlesse they have as it were a naturall carefulnesse of their owne commoditie, as not ignorant how great estimation we mortall men make of the same amongst us, and therefore so soon as the fishermen doo catch them, they bind their shells togither, for otherwise they would open and shed their pearles of purpose, for which they know themselves to be pursued." p. 15.—Mr. Roberts almost emulates Boethius when detailing some interesting peculiarities in the habits of the Patellæ.—*Ann. and Mag. N. Hist.* xix. 70.

and which vary in number and in perfection in the different tribes. Our account of these it may be convenient to preface with a very short and general sketch of the nervous system, as from it emanate all their powers.

In the compound Tunicata the existence of a nervous system is doubtful; and in the Ascidians it is only slightly sketched. Here its chief centre or ganglion is situated "in the interspace between the two openings of the muscular tunic," and from this centre branches are sent to each aperture, to the respiratory sac, and to the digestive organs. In the Brachiopods the system is not more developed than in the Ascidians, and in some genera is very obscurely adumbrated. In the proper mollusca the system consists of several ganglions, always paired and associated together by filaments or nerves. One pair, usually called cerebral and considered analogous to the brain of vertebrates,* is situated on the dorsal side of the body in front and above the gullet, and is connected by two filaments to a pair of abdominal ganglions placed further backwards and on the gullet's opposite side, which is thus encircled with a collar of double nerves. A third pair of ganglions, in general less developed than the others, is found under the anterior extremity of the œsophagus, and communicates with the cerebral by two filaments that form a circle similar to the one already mentioned. These are the labial ganglions. They are absent in some genera, while, in others of the same order, additional ganglia even are found; but the differences in the complexity of the nervous system depend ordinarily on the degree of developement of the centres already specified, and in their more or less nighness to each other. Thus in some mollusca low in the scale, as in the Razor-shell (Solen), the cerebral ganglions are very widely set apart; yet even these are always united by a commissure, and the abdominal ganglions are placed at the opposite extremity of the body, so that the filaments representing the œsophageal collar are of comparatively excessive length. Thus also in the Ianthina, the four œsophageal ganglions are still distinctly isolated, but the posterior pair are so closely approximated to the cerebral that the connecting commissure encircles the œsophagus with a strict embrace. In the snail, and in a crowd of others, the centralization is carried further, for both the cerebral ganglions and the sub-œsophageal touch on the mesial line,

* Improperly, I believe. "Les nerfs qui viennent du cerveau se distribuent plutôt comme ceaux de la vie organique, ou le grand sympathique, que comme les nerfs cérébro-spinaux des vertébres."—Cuvier, *Hist. Sc. Nat.* iii. 60. M. Serres denies that the mollusca have a brain.

and this portion of the nervous system, appears to be composed only of two unequal nervous masses. In the Cephalopods the coalescence of the ganglions is more intimate, so that they now form a continuous circle of nervous matter around the gullet, enclosed in a cavity in the posterior part of the cartilage of the head — in, in fact, a sort of rudimentary skull. Thus you observe, that the nervous system advances in a regularly proportional degree with the complexity of the general organization, and especially with the muscular system.*

From the various ganglions nerves depart to carry the influence of their centres to the different organs of sense, and to the various viscera. These filaments are usually simple. In many of the higher groups of mollusks some of them trend to and unite with other ganglions, thus more intimately connecting distant parts together. These secondary ganglions vary in position with the varying modifications of the whole structure, and are unsymmetrical; and this want of bilateral symmetry has led Professor Owen to denominate the class or sub-kingdom, Heterogangliata.† The nerves themselves cannot be resolved into smaller filaments, like those of vertebrate animals; they are formed apparently of a soft homogeneous medullary matter, surrounded with a sheath so loosely adherent thereto that it can be filled with injections; whence some have been led to suppose that the nerves are hollow, and others that the tunics are the vessels of the lymphatic system. The colour of the ganglions in some mollusks is remarkable. Cuvier found them bright red in the Limneus stagnalis and Planorbis cor-

* This slight sketch, sufficient for our purpose, is derived from Milne-Edwards Elémens de Zoologie, 241—244. The English student has excellent resources to extend his knowledge of the subject in the elementary works of Professors Grant, Owen, and Jones.

† "In the mollusca, the nervous system is principally concentrated around the entrance to the alimentary canal, forming a circle of ganglia through which the œsophagus passes, and which is connected with other ganglia, disposed without symmetry among the viscera, or in the neighbourhood of the organs of locomotion, if such should be specially evolved. In some of the highest of this division, the nervous system approaches very closely in its arrangement to the form it presents in the lowest vertebrata, and receives a corresponding protection by a rudimentary internal skeleton; but, in general, it is more connected with the immediate supply of the nutritive functions, and wants that symmetrical arrangement and close connection with the locomotive organs which may be regarded as characters of elevation in the nervous system of the Articulata. From the general plan of the distribution of their ganglia, mollusca have been termed *cyclo-gangliata*."—CARPENTER'S *Gen. and Comp. Physiology*, p. 71. The latter name is that bestowed on the class by Professor Grant.

neus; in some Aplysiæ they are blackish-red and granular; and in our native Aplysiæ they are yellow. Carus asserts, that those of the common fresh-water mussel are invariably bright yellow;* in the Arcæ, Pinnæ, and a few others, they are tinted a rose-red, but in the majority of Bivalves they are yellowish, or almost white, and soft and transparent.

I will now tell you all I know about the senses of the mollusca, and will begin with that of touch, as it is common to the whole class, and consequently the most important. It is, indeed, doubtful whether the bivalved mollusca have any other sense; they have no undisputed eyes, no true tentacula, no tongue, slight vestige of an ear, and if they possess the perception of smells, we know no organ in which it is localized;—"neither, indeed," says Bradley, "do I think the necessary organs for those senses can reasonably be sought for in such bodies as have a fixed state of life; the senses of feeling and tasting being sufficient for the maintenance and support of them."

I. TOUCH.

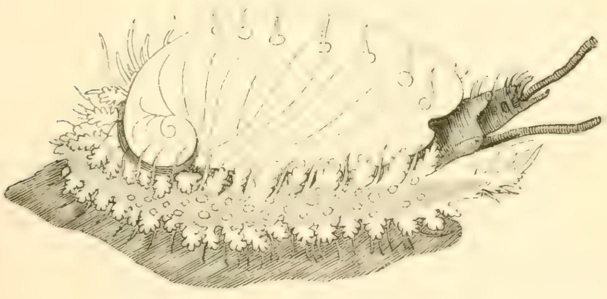
The skin of the mollusca is a soft, spongy, mucous membrane, wrinkled and thickish where exposed, smooth and very thin where covered with the shell. It is never in the slightest degree hairy, or villous, or horny, but always kept in a moist state by a glutinous secretion, exuded in some instances from "little, glandulous, unequal grains," profusely scattered over the surface; in others, from crypts or glands confined to particular parts. It is a homogeneous membrane, not divisible into epidermis and cutis vera, like the skin of the vertebrate animals; and it is so intimately fixed to, or rather interwoven with, the subjacent muscular layer, that it is contractile at every point, and in all directions. It invests every part, sometimes closely, but more commonly there is "ample room and verge enough" to form folds and expansions; from which circumstance it has received the name of *mantle* or *cloak*. The blood-vessels distributed in its texture are very numerous, and the nerves are presumed to be at least equally so.

From this structure we might have concluded that the skin would be peculiarly sensible to external impressions; and this we know is the fact. Let your experiment be made with the lightest hand and the softest instrument, yet it cannot come into contact with the mollusk which

* Comp. Anat. trans. i. 53; also, Edinb. New Phil. Journ. vii. 229.

will not feel the impression, and evidence its alarm by intelligible signs. The intimations which they receive by this medium are probably of a very general character, and have respect only to the motion, the temperature, the hardness or softness, of the impressing body. To judge of the position, and perhaps in some degree of the form, of bodies, they are provided with special organs, which, when situated on the head, or about the mouth, are denominated *tentacula*, but when arranged along the sides or on the margins of the cloak, more commonly *tentacular filaments*. The former are two or four in number, very rarely six,* and in only one or two instances is there a pair, with an odd one behind them: they are of a cylindrical, tapered, or triangular figure, very flexible, and almost always capable of being withdrawn within a sheath or under the collar, at the will of the animal. The filaments are sometimes retractile, and sometimes not: many species do not possess them; but, when they are present, they become the creature's chief ornament. The shell of the Haliotis, for example, if we except the splendid iridescence of its interior, is sufficiently plain and vulgar; but behold it borne along by the living tenant, its

Fig. 32.



variegated garniture all displayed and vermicular in the smooth and crystal water, and it moves wonder and admiration (Fig. 32). The Cypræ, Trochi, and the family of which the genus Turbo is the type or representative, afford equally fine illustrations, the filaments in some species

* The Nautilus is remarkable for their unexampled number, surrounding the mouth in successive series, and amounting to little short of a hundred! They are also retractile within sheaths, and annulated; but it should be remembered that of this number *four* only seem designed for sensation, and these resemble the tentacula of Doris in their lamellated structure. See Owen's Memoir; and Cyclop. Anat. and Physiol. i. 526.

being delicately ciliated. Among bivalves a fringe of these filaments is very general. In the genera which have the cloak completely open, as the oysters, and the sea and fresh-water mussels, the filaments fringe it all round; and in those in which the cloak opens by a tube only, these appendices, either simple or variously scalloped, are attached to the circumference of its orifice. Such is the case in the genera Venus, Cardium, &c.

Now, these tentacula and filaments are exquisitely sensitive, and in all likelihood, convey impressions of a more distinct character than the general surface. When the mollusca walk abroad, these organs are all extended to the utmost, and in perpetual motion; sentinels alive to everything around, warning against foe or danger, and watchful of prey. By means of them, the Gasteropods likewise feel their way, and ascertain the nature of the ground they traverse, as it seems evident from the manner in which they use them; but to this purpose the proper tentacula are never applied,—at least when they carry the eyes on their tips; and they appear to be organs of some other sense. If removed, the snail creeps on as if it were unmutilated; and there are tribes, among which we may instance the entire order of Nudibranches, in which their position is such, that they cannot possibly be applied to objects either in front or around them.

II. TASTE.

Swammerdam found, by experiment, that snails have "a nice appetite and taste;" and it seems necessary to suppose the existence of this sense in all mollusca, for they select particular articles of food in preference to others; and we know no other sense which is fitted to regulate the choice. It must reside, of course, in the mouth; but, whether diffused over the whole, or limited to a certain space, it were hard to determine. Blainville thinks that in the cephalous mollusca, the seat of taste may probably be in a knob or swelling at the lower end of the buccal cavity; and Cuvier conjectures that the tentacula, at the orifices at which the water, the vehicle of their aliment, enters, may exercise this sense in the acephalous ones.*

III. SMELL.

According to Swammerdam, snails have a very quick smell. "This I observed," says he, "when I moved a

* Comp. Anat. trans. ii. 694.

little fresh food towards them, for they immediately perceived it by the scent, and crept out of their little shells, and came to it."* Gaspard appears to have repeated this experiment without success †; but he is surely hasty in denying, on that account, the existence of the sense, seeing how positively the contrary is affirmed by one of the greatest and most honest of naturalists. Blainville says, in general terms, that the acephalous mollusca have no smell, but he admits that the Cephalopods and Gasteropods possess the sense, and the terrestrial species in a degree of considerable delicacy, since we observe that slugs and snails seek out particular plants, where sight could not have availed them. According to Carus, it appears to be fully proved by the observation of the aversion of these animals, the Sepiæ for instance, to strong-scented plants, that those mollusca which live partly in water and partly in air, have an olfactory organ, but he denies its existence in those which live exclusively in water.‡ Admitting the existence of the sense in the cephalous families, there remains great uncertainty relative to its seat. Analogy is here at fault, for invertebrate animals have nothing similar to a nose. Cuvier thinks that a special organ may not be necessary, for the whole skin appears to resemble a pituitary membrane, and may, in consequence, be susceptible of receiving the peculiar impressions emanating from odorous bodies.§ If, however, a particular seat for the sense is to be fixed upon, he would place it at the entrance of their pulmonary cavity, because, in all vertebral animals, it is situated at the entrance of the organs of respiration; an argument of little value in the present instance. Blainville, whose opinion is always entitled to attention, states his belief that the proper tentacula are the olfactory organs, because the skin of them is more soft, smooth, and delicate than on any other part, and their nerves more considerable; || argu-

* Book of Nature, p. 49. † Zool. Journ. i. 179.

‡ Comp. Anatomy, i. 74. According to Oppian the Octopus may be induced to leave the sea by placing branches of the olive-tree on the shore; and Cuvier thinks that this is a statement which deserves to be verified. Hist. des. Sc. Nat. i. 308. § Comp. Anat. trans. ii. 688.

|| Manuel, p. 107, or more particularly his excellent Principes d'Anatomie Comp. i. 341. Dr. Leidy places the sense, in the terrestrial Gasteropods, in a sort of cul-de-sac, "having its orifice beneath the mouth; between the inferior lip and the anterior extremity of the podal disk, and which in many species of different genera is elongated backwards into a blind duct, more or less deep, occupying a situation just above the podal disk within the visceral cavity." This opinion deserves re-examination.—*Ann. & Mag. N. Hist.* xx. 211.—The structure itself had been observed previous to Dr. Leidy's examinations. See p. 170, note §.

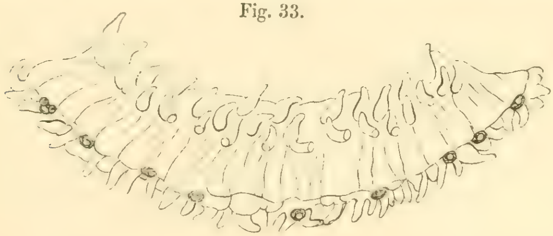
ments of too general a nature to have any influence when adduced for a special purpose. He might have found, perhaps, a better proof in their position, for in very many genera the tentacula do not support the eyes; nor are they, nor can they be, employed in tracking the way. This is the case in the family Doridæ, in which the tentacula are situated on the back, point directly upwards, are remarkably large, and of curious and complex organisation, being formed of a series of imbricated lamellæ, like the antennæ of some coprophagous beetles. The tentacula of the Tritoniadæ is equally complex, being cut into numerous fimbriated segments; and in Scyllæa these organs are in some degree cupped, a little conical appendage rising up out of the capsule. From a consideration of these and other instances of peculiar organisation in the tentacula of the mollusca, we cannot but suspect that they exercise some important office in the animal's economy; and since they are all unsuited for vision or touch, no other sense but that of smell remains to assign them, for we have found that the mollusca in question, are not affected by noises of any kind. This suspicion, long entertained on our part, has been converted into an almost certain truth by the admirable dissections of Mr. Albany Hancock and Dr. Embleton. They have shown how closely similar the lamellated structure of the dorsal tentacles in the Nudibranchiates is to the olfactory organs of some fish, and of the Nautilus; and the deduction which this similarity of structure would warrant, they have further shown to be true, by the source whence they derive their nerves, and the great size of them. A confirmatory fact has been added by Mr. Alder, who noticed "that the cilia on their surface vibrate in a direction contrary to that of those on the surface of the branchial papillæ. On these the cilia move constantly from the body towards the extremity of the papilla; on those they act from the point of the tentacle towards the body: thus, in the former case, the water which has served for respiration is drawn from the body and thrown off from the apices of the papillæ; whilst in the latter the fluid which we may suppose to contain odorous particles or qualities is attracted to the end of the tentacle, and made to pass down over the entire surface, and then thus to act upon the sentient nerve within."*—Mr. Owen is of opinion that there exists "a distinct organ of passive smell" in the Nautilus, formed after the type of that organ in the inferior vertebrata, and especially in fish. This part "consists of a series of soft membranous laminæ compactly arranged in the longitudinal

direction, and situated at the entry of the mouth, between the internal labial processes. These laminæ are twenty in number, and are from one to two lines in breadth, and from four to five in length, but diminish in this respect towards the sides. They are supplied by nerves from the small ganglions which are connected to the ventral extremities of the anterior sub-œsophageal ganglions."†

IV. SIGHT.

That the tunicated and bivalved mollusca are destitute of eyes has been long an axiom with conchologists,‡ but recently some exceptions, of a somewhat doubtful character it must be confessed, have been pointed out. Placed between the oral tentacula, as also between the filaments of the vent, of certain Ascidia, there is a series of eight and six little scarlet globular points, which are so like the organs that Ehrenberg affirms to be eyes in the medusæ and starfish, that it is impossible to doubt the sameness of their functions. So also in a few bivalves, of which the Pectens and Sphondyli are the most eminent examples, there are many green metallic lustrous beads placed, at stated intervals, on the margins of the cloak among the tentacular filaments (Fig. 33). The use of these beautiful organs re-

Fig. 33.



mained unguessed, until Poli gave it as his opinion that they were subservient to vision; whence he named the animal of the Pecten, after Juno's watchman, the Argus, to whose mantle you may suppose the hundred eyes of the fabled son of Aristor had been transferred. How far Poli's

* Ann. and Mag. N. Hist. ser. 2. iii. 194.

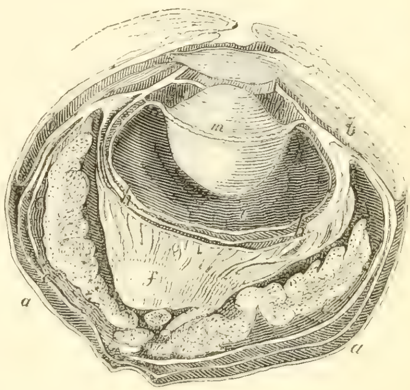
† Memoir, p. 41.

‡ "No organs having the most distant relation to the sense of vision, have ever been observed in any of the acephalous or bivalve mollusca."—Roget's *Bridgew. Treat.* ii. 481.

opinion may be correct, I cannot say;* but a physiologist of great ingenuity has inferred that in the bivalves in question there is a sense analogous, at least, to that of ordinary vision, from their quick and varied motions, and from the fact that the Trigoniæ, in their attempts to escape from a boat, leap in a definite direction, as Mr. Stutchbury had witnessed.†

The great majority of the Pteropods, though apparently influenced by light, and a few marine naked Gasteropods, are eyeless; § but organs which have been generally considered as serving the purposes of vision, have been bestowed on all other mollusca. There can be no question of their function in the Cephalopods, for in them the eyes are very large, and similar, in all essential points, to those of vertebrate animals. They are two in number, one on each side of the

Fig. 34.‡



* "Each of these *ocelli* possesses a cornea, lens, choroid, and nerve: they are, without doubt, organs of vision."—Garner in *Mag. Nat. Hist.* n. s. iii. 128.—"Will has instituted researches on the eyes of the Conchifera He found them to be very highly organised. Besides Pecten, Sphondylus, and Ostrea, he found them also in Pinna, Arca, Pectunculus, Mytilus, Cardium, Tellina, Mactra, Venus, Solen, Pholas, sometimes in vast numbers."—*Reports on Zoology* for 1844, p. 439, printed for the Ray Society, Lond. 1847.

† Carpenter's Gen. and Comp. Phys. pp. 98, 99.

‡ The figure is a view of the eye of Octopus vulgaris, copied from Cuvier. *a a*, A cellular and muscular tunic, the latter for opening the lids; *b b*, the conjunctiva; *c*, another tunic, enveloping the globe of the eye, and a pouch situated behind it (*e*), containing (*f*) the optic ganglia, and the glands which surround it (*g*). The pouch (*e*) is a transparent membrane, which occupies all the space between the globe of the eye and the tunics which go to its lids; so that the former actually fills only about a third of the greater globe, which, at first view, appears to be the eye itself. *h h*, The external coat of the proper eye, perforated with an infinite number of minute holes, for the passage of the filaments from the optic ganglion; and *i*, another coat, formed apparently by the expansion and netting of these nervous filaments. *m*, The crystalline lens.—I may also refer to a description and figure of Loligo sagittata in the *Edinb. Journ. Nat. and Geogr. Sc.* iii. 286.

§ The existence of eyes in Doris and Goniodoris,—genera that had hitherto been described as entirely devoid of these organs,—has been proved by my friends Alder and Hancock, of Newcastle. They are to be most distinctly observed in young individuals.—*Ann. Nat. Hist.* ix. 31.

head; they are capable of being moved to a slight extent; they are formed with coats, humours, and nerves, so arranged that, on physical grounds alone, we may confidently pronounce them to be optical instruments of considerable power (Fig. 34). The structure is most perfect in the Loligo and Sepiæ; it is less so in the Octopus; and in the Nautilus has become so simplified that there is some reason to suppose the sense of sight in it to be reduced to the simple consciousness of the reception of light.

The case is greatly different with the reputed eyes of the Gasteropod mollusca. From their minuteness it is difficult to unravel their structure; and, in many instances, they are so situated that, were they organs of vision, the creature, it is presumed, could be little benefited by them. Moreover, it has been asked of what avail it would be for an animal to discover distant objects, which could neither overtake them if necessary for food, nor avoid them if inimical to its existence; and it has been asserted that the eyes of snails, at least, are in every respect insensible to light, for the creatures creep and climb as correctly in the dark as by daylight; they do not at any time perceive obstacles, placed on purpose in their way, until they touch them; and when deprived of the organs they crawl on as unconcernedly, and guide themselves as safely, as they did previously to the mutilation. On these grounds some naturalists of eminence have denied that the little black points, denominated eyes by the vulgar and the learned, are ocular bodies, and find in them nothing more than the organs of an exquisite sense of touch.*

Organs of touch they may be in Snails (Helix, Limax, &c.), in which they are elevated on movable and filiform tubes capable of being directed to all points; but organs of touch they surely cannot be in the greater number of the class, on which they are placed, as it were purposely, to be removed from the contact of external objects. Such, for example, is their position in the Whelks (Buccinum) and Rock-shells (Murex), in the Lymnæidæ, Turbonidæ, and others. Seeing, too, how amply the mollusca are otherwise furnished with tactic organs, additional ones might be deemed superfluous; and, notwithstanding the facts opposed to it, I am firmly of opinion that what have been called the eyes have been properly so designated,—organs susceptible not merely of the impressions of light, but capable of distinguishing ob-

* Gaspard in Zool. Journ. i. 179. Also, Lister in Phil. Trans. abridg. ii. 139.

jects, and perhaps colours. They are placed on the anterior part of the body, as the eyes of every other animal are; their size and number are constant in individuals of the same species; they bear a very exact resemblance to the eyes of many insects, and to the stemmata of others, which are believed to be eyes; and the snail, when confined, makes unequivocal attempts to turn that part of the body which is furnished with them to the light.* I have occasionally, on a summer's dewy evening, when the animals were on the alert, made experiments on our common slugs and snails; and I am satisfied, as Lister appears to have been, † that they do perceive obstacles placed in their way, diverging from them when within from one to three inches. They rarely touch the opposing substance, but often they alter their course so slightly as to pass it by in freedom with a shortening of the tentaculum on the near side, while sometimes the track is changed entirely. Nay, I have seen, or imagined I have seen, in more than one instance, a snail follow, with apparent eagerness, the purple-coloured flower of a thistle held near its tentacula, and gradually withdrawn. ‡ Adanson very readily distinguished the lens and iris in the eyes of the Cyprææ, whose sight, he asserts, is pretty acute—"assez fin;" § and Swammerdam affirms that the Littorina littorea draws itself suddenly within the shell when anything is suddenly presented to its eyes; "so that," he adds, "I may venture to affirm from hence, that this is the only species of snails that I know wherein any manifest signs of sight appear." || Further, such mollusca as have oculiferous tentacula do not use them in touching objects; for, as Mr. Guilding has properly observed, they carry them usually erect; and the inferior ones, with the lobes of the cheeks, are principally used as tactors.

I grant to you that these arguments are not decisive of the question, and that one drawn from the anatomical structure of the organs would be of superior convincement; and that argument is now, thanks to the dexterity of modern anatomists, entirely in my favour. In the Cypræadæ and the allied families, the structure of the eye is said to be by no

* Müller, Verm. Hist. i. præf. 3. et 4.

† Lister's Exercit. Anat. de Cochleis, p. 10. 1694, 12mo.

‡ "Experiments are said to have been recently made, both by Leuchs and by Steifensand, in which a snail was repeatedly observed to avoid a small object presented near the tentaculum; thus affording evidence of its possessing this sense."—Roget's *Bridgw. Treat.* ii. 482.

§ Senegal, p. 71.

|| Book of Nature, p. 81.

means obscure; * and the giant Strombidæ, which inhabit the Caribbean Sea, have eyes more perfect than those of many vertebrated animals. They have, according to the late Rev. Lansdown Guilding, a most intelligent and indefatigable naturalist, a distinct pupil and a double iris, equalling in beauty and correctness of outline those of birds and reptiles; and he discovers in the organ a vitreous and an aqueous humour, and the black pigment. † Mr. Gray, a naturalist of equal industry and accuracy, tells us that if they who have doubted concerning the nature of these organs "had examined the eyes of the marine carnivorous mollusca, Buccinum undatum or Fusus despectus, and more especially some of the larger Strombi, they would have found the eye as fully developed as in the cuttle-fish, showing the cornea and the nearly orbicular crystalline lens almost perfectly formed, as may be seen by any person simply cutting the cornea across, and slightly pressing it, when the crystalline lens will protrude." ‡ This evidence seems conclusive; for if the same parts cannot be demonstrated in the smaller or in the terrestrial mollusca, it is surely because of the minuteness of the organ and the difficulty of the dissection. But the fact is, that Swammerdam has described, with great minuteness, the eye of the common snail, in which he detected "five distinct and visible parts," viz. the uvea, the aqueous, the crystalline, and the vitreous humours, with the arachnoid tunic; parts which, he affirms, were as "clear as the sun at noon." He likewise observed that the eyes of the Lymnæi were provided each with "its own proper crystalline humour." The accuracy of this description has been denied,—as indeed this good man, and incomparable anatomist, seems to have foreseen would be the case. "But who can credit this?" says he; "for it seems indeed improbable, that on a point not bigger than the nib of a writing-pen, such exquisite art, and so many miracles, should be displayed." §

* See Blainville's anatomy of the eye of Voluta cymbium, L., in his Princ. d'Anat. Comp. i. 445.

† Zool. Journ., iv. 172. Also, Swainson on Hab. and Inst. of Anim. p. 43. "In the typical Strombi, these organs are so much developed that the iris is richly coloured, and the eyes of some of the larger species have been described to us as particularly beautiful."—Swainson's *Malacology*, 136.

‡ Edinb. Journ. Nat. Geogr. Sc. iii. 52.

§ Of Swammerdam's anatomy of the Snail, Cuvier says, "Il en fait connaître toutes les parties, le cœur, les viscères, le foie; il en décrit tous les muscles, et explique toutes les manières dont cet animal est attaché à sa coquille. Il fait connaître ses yeux, leur cristallin, la nerf optique qui s'y rend

Swammerdam's description of the organ is, indeed, in some degree inaccurate. He mistook the large nerve contained in the interior of the cylindrical tentaculum of the snail, and which, according to the variable condition of the tentaculum, is sometimes bent or waved and sometimes straight, for the optic nerve,—a mistake in which he has been followed by all subsequent anatomists, until Professor Müller, of Bonn, proved that this strong nerve does not go to the eye, but to the extremity of the tentacula, where it terminates in the form of a papilla. The true optic nerve is a very fine filament running alongside this larger one,* diverging from it about a line and a half from its extremity at an acute angle, and passing forwards to the eye, which is situated, not on the apex of the tentaculum, but a little to a side, and is of very small size. It "is almost spherical, a little flattened anteriorly. It is covered in front by a very thin transparent layer of the external skin, and is surrounded, laterally and posteriorly, by an entirely black choroid. This black globule contained, in all the individuals examined by Müller, a transparent and semi-fluid substance, apparently entirely filling the eye; at the bottom it seemed more fluid, and appeared to contain many brilliant particles when the eye was dissected under the microscope. In the anterior part of the eye is a small discoid or lenticular body, perfectly clear and transparent, and composed of the same semi-fluid matter which filled the bottom of the eye, differing only from it in being a little more dense. In all the specimens of the snail which Müller examined, the transparent matter was not solid, and the discoid crystalline itself was semi-fluid and compressible. In the Murex Tritonis this lenticular portion is quite hard, and of an amber colour."†

All doubt, then, relative to the reality of the eyes of the mollusca may be said to be removed; and when I consider their structure, and their very general existence in the class, I am far from joining with those who believe them to be of

au travers des cornes; toutes choses si délicates, qu'elles parurent une sorte de merveille, de miracle, tant de la part de celui qui les avait observées, que de la nature qui les a faites."—*Hist. de Sc. Nat.* ii. 429.

* "With regard to the optic nerve of Gasteropods, anatomists were formerly in error, mistaking for it the great nerve of the tentacula, which is the nerve of touch; the optic nerve is much more minute, and *looks like a branch* of that larger nerve, but may be traced backwards to the cerebral ganglion."—Muller's *Elem. of Phys.* trans. p. 1117. Roget's *Bridgew. Treat.* ii. 481.

† Edinb. Journ. Nat. and Geogr. Science, iii. 283. An historical account of the discoveries in the anatomy of the eye of Gasteropods, is given in the Ann. des Sc. Nat. xxii. 7—19.

little service to the animal, enabling them at most to distinguish light from darkness.* Even this limited use, however, may be here important, for as a great number of mollusca are nocturnal in their habits, their eyes may act as sentinels to warn them of the approach of day and of danger, and that it is now time to seek places of retreat and safety.

The eyes are always two in number, generally minute, although perhaps not disproportionably so, black, convex, and glossy, and incapable of any independent movements; but their position relative to the body is often altered by the motion of the parts on which they are placed. In the Gasteropods they are always lateral or dorsal; sometimes they are placed on the body behind or between the tentacula, as in Aplysia; often they are at the base of the tentacula, and not unfrequently in a notch on their sides at a greater or less elevation.† In some genera, as in Strombus and Natica, the eyes are on the summit of pedicles appropriate to themselves; and in the Helices and Limaces they mount near to the apex of the superior tentacula. These are fleshy tubes, which, as you well know, may be drawn completely within the head, and again protruded by a motion similar to the evolution of the finger of a glove. The muscle which withdraws the tube arises from the muscles that draw the snail into its shell, and, running forward, is fixed to the extremity. When, therefore, it contracts, but still more when assisted by the contraction of the great muscle of the body, the apex

* Swammerdam infers that "the sight of the snail must be very dim. I could not, at least hitherto, observe that the snail sees well the things which are near it, notwithstanding all the attempts I made for this purpose."—p. 48. Of the Nudibranchiata, Hancock and Embleton say,—"The degree of the vision enjoyed by these animals must be slight. They can distinguish light from darkness, and can probably appreciate imperfectly different degrees of light; and as the eyes are placed under the skin of the head, their perception of objects must be exceedingly faint and indistinct."—*Ann. Mag. N. Hist.* ser. 2, iii. 196.

† Mr. J. E. Gray has the following generalisations:—

1. Mollusca which have the eyes sessile on the outer side of the tentacula, have the sides of the body simple or unfurnished with filaments; and the mantle of the operculum is also simple. Lacuna is an exception, having a small process on each side of the hinder part of the opercular mantle.

2. Mollusca which have the eyes pedicelled, have the mantle of the operculum extended along each side of the body with lateral filaments on its margin, or just beneath it; and in an interruption of its front are placed the eye pedicles and the proper tentacula. The front of this mantle is also continued over the head to form a continuous hood, or two or more crests. The exceptions are Nerita, Neritina, and Ampullaria, which have pediceled eyes, but appear to want the lateral membrane. In the Syn. Brit. Mus. for 1842, Mr. Gray has used these characters to separate the groups of the principal sections.

of the horn is drawn inwards, in a manner which resembles the turning in of a stocking. The annular fibres which encircle the horn throughout the whole of its length, unfold the internal part by successive contractions, and thus bring back the eye to its external position. *

The location of these organs has been varied according to the wants and habits of the animal, and to the medium in which it was destined to live; but neither this medium nor these habits have had the slightest share in producing the variations; a remark so obvious, that it may well seem to you unnecessary, did not the language of too many naturalists imply something to the contrary. †—The notion is akin in absurdity to another doctrine which Lamarck in particular has strenuously and long endeavoured to establish, viz. that the eyes (and of course the same reasoning applies to the organs of the other senses) are the products or manufacture of strong desires on the creature's part to enjoy the blessing of sight. "The production," he says, "of a new organ in an animal body is the result of a new supervenient need which continues to be felt, and of the new motion which this need has originated and keeps up:" and as an illustration of this law, which he is careful to print in italic letters, he instances the snail, which, in crawling along, finds the necessity of touching the bodies which are before it, makes efforts to do so with some of the anterior prominences of the head, and sends there every moment waves of nervous fluid and of the other liquids. Now, the result of these repeated tides on the points in question, is a gradual extension of their nerves, a gradual growth of their substance, and the ultimate budding and evolution of two or four tentacula. ‡ Do not think that I overstrain the doctrine, for indeed I trans-

* Cuvier, Comp. Anat. trans. ii. 444.—"We observe," says Müller, "in the cavity of the terminal portion of the tentaculum, a little liquid which seems to be of service in facilitating the evolution of the organ."

† See a very objectionable passage quoted from Férussac, in Zool. Journal, ii. 505.

‡ Anim. sans Vertébres, i. 185—188. The doctrine of Lucretius is antipodal to Lamarck's, and just as true:—

"Note here, Lucretius dares to teach
(As all our youth may learn from Creech)
That eyes were made, but could not view,
Nor hands embrace, nor feet pursue:
But heedless Nature did produce
The members first, and then the use.
What each must act was yet unknown,
Till all is moved by chance alone." PRIOR.

late the words of my author with sufficient closeness and sobriety; and had he not been silent on the points, I would also have told you wherefore the desire awoke in some and still sleeps in others; from what cause it happened that a creature born blind, and all unconscious, became conscious of the existence of light, and felt the wish to see this fair scene; and by what more than magnetic influence this longing wish arranged the particles, and moulded them so curiously, that an ordinary mind can perceive only the designing hand of an intelligent First Cause. These are perhaps questions of little moment, and you must rest satisfied with the dicta of the teacher:—

"For when each would have open'd its eyes
For the purpose of looking about them,
They saw they had no eyes to open,
And that there was no seeing without them!"

You will find that, in the second volume of his "Principles of Geology," Sir Charles Lyell has examined at great length, and more seriously, Lamarck's doctrines; and the examination is rendered interesting by the manner in which he has conducted the discussion. I need scarcely remind you that Lamarck is not the author of his theory; it is the revival of a doctrine of ancient date. Bacon warned us against it:—"Again, when man reflects upon the entire liberty of nature, he meets with particular species of things, as animals, plants, minerals, and is thence easily led to imagine that there exists in nature certain primary forms which she strives to produce, and that all variation from them arises from some impediment or error which she is exposed to in completing her work, or from the collision or metamorphosis of different species. The first hypothesis has produced the doctrine of *elementary properties*, the second that of *occult properties and specific powers;* and both lead to trifling courses of reflection, in which the mind acquiesces, and is thus diverted from more important subjects."* At a period, too, only a little anterior to Lamarck, we find that Dr. Darwin advocated the same doctrine with his usual fanciful ingenuity and decisiveness; and I transcribe for you the following answer to him, because it occurs in a book now rather rare, albeit of great authority in questions of this kind, and which is seldom consulted by naturalists:—"Dr. Darwin," says my authority, "seems to consider the animals of former times as possessing powers much superior to those of their posterity. They reasoned on their wants: they wished, and

* Nov. Organum, § 66, p. 37.

it was done. The boar, which originally differed little from the other beasts of the forests, first obtained tusks, because he conceived them to be useful weapons, and then, by another process of reasoning, a thick shield-like shoulder, to defend himself from the tusks of his fellows. The stag, in like manner, formed to himself horns, at once sharp and branched, for the different purposes of offence and defence. Some animals obtained wings, others fins, and others swiftness of foot; while the vegetables exerted themselves in inventing various modes of concealing and defending their seeds and honey. These are a few of many instances adduced by Dr. Darwin, which are all objectionable, on his own principles; as they require us to believe the various propensities to have been the cause rather than the effect of the difference of configuration. The fish did not become a sub-natant animal by having received fins, as it must have been an inhabitant of the water before it could have felt the want of them; and the hog must originally have had propensities different from those of the sheep, or it would not have wished, nor attempted, the formation of its snout.

"Of all modes of reasoning that is the easiest which contents itself with simple supposition; but to this species of argument no bounds can be fixed. It will prove as readily that a single filament gave rise to the complicated system of the universe, as that it gave rise to all the tribes of animals and vegetables that inhabit our earth.

"If we admit the supposed capacity of producing organs by the mere feeling of a want, man must have greatly degenerated, or been originally inferior, in power. He may wish for wings, as the other bipeds are supposed to have done with success; but a century of wishes will not render him abler to take flight. It is not, however, to man, that the observation must be confined. No improvements of form have been observed in the other animals since the first dawnings of zoology; and we must, therefore, believe them to have lost the power of production, rather than to have attained all the objects of their desire. If we may be allowed to judge from their situation, the hare has still in the chase the same reason as the birds of old to wish for wings, and the dove for greater swiftness of flight to escape from the pursuing hawk; yet the scale of inferiority still subsists; and such is the order of nature, that the strength of all is supported by the weakness of all." *

* Brown's Observ. on Zoonomia, p. 264—267. See also remarks by Professor Agassiz in Edinb. New Phil. Journ. for July 1846, p. 31.

V. HEARING.

An auditory organ has been demonstrated in so many species, that it may be considered a very general possession of the mollusca. Its existence in the Cephalopods was known to John Hunter; MM. Eydoux and Souleyet have found it in several Heteropods, and, at least, in one Pteropod; and it has been seen by M. Laurent in several genera of this order. Van Beneden and Krohn have likewise described the hearing organ of several Heteropods; and its structure in the Nudibranches has been anatomized by De Quatrefages, and more especially by Messrs. Embleton and Hancock. However, we owe our knowledge of the organ principally to M. Siebold, who has pursued his researches more systematically than any other anatomist, and further has proved its existence in many Gasteropod and bivalve acephalous mollusca. Like the other organs of sense, the ear is always paired. It is formed by two hyaline, ovate, or orbicular capsules, situated on the head or neck at the bases of the tentacula, and is supplied with its specifically-endowed nerve from the cerebral ganglions.* In the capsule there are enclosed one or several (and sometimes they are numerous) oval or round crystalline bodies named otolites; and it is observable that the number varies not only in neighbouring genera, but even in nearly allied species. Siebold says that a concentric depression is evident in these otolites, and there may be seen in the centre of the greater number of them a shaded spot, or rather a minute aperture, which penetrates through the concretion from the one flattened surface to the other. Subjected to

* "En effet, cet organe se trouve chez tous les Gastéropodes à la partie postérieure des deux renflemens ganglionnaires les plus volumineux; on doit les chercher toujours auprès de la paire de ganglions antérieurs de cette portion de système nerveux, et il est plus facile de les trouver à la surface inférieure qu'à la surface supérieure, surtout chez les Gastéropodes (Limax, Helix), dont les divers ganglions sous-œsophagiens sont confondus de le manière la plus intime."—SIEBOLD *in Ann. des Sc. Nat.* (1843), xix. 198.—In the Bivalves the organ is placed in the foot. Siebold thus describes it in Cyclas cornea: "On compressing the extremity of the foot of this species between two plates of glass, we bring into view a large or central nervous ganglion; and on each side of this there is a minute round reservoir, composed of an elastic, opake, and tenacious mass. In the centre of this there is again a perfectly transparent circular and flattened nucleus, which floats disconnected from the sides of the body that contains it, and has an oscillatory movement. This nucleus appears to consist of a crystalline salt." —*Ann. des Sc. Nat.* n.s. ix. 319.

a strong pressure, the otolites crack in radiating lines, separating often into four pyramidal pieces. This separation also ensues, after a longer time, when the otolites are immersed in a diluted nitric acid; and if we touch them with the concentrated acid, they suddenly dissolve with the disengagement of a gas, whence Siebold concludes them to be composed of carbonate of lime. The size of the otolites is not equal; and, in the same capsule there are always some which are smaller than others. Within the capsule they have, during life, a very remarkable and, in some respects, peculiar, lively, oscillatory movement, being driven about as particles of any light insoluble powder might be in boiling water. The otolites in the centre have the appearance of being pressed together so as to form a sort of solid nucleus; and towards this centre the otolites towards the circumference seem ever to be violently urged, their centripetal rush being invariably repulsed, and as often driven again into a centrifugal direction. Removed from the capsule, the motions of the otolites instantly cease. The cause of these curious oscillations remains undiscovered. Siebold could detect no vibratile cilia on the surfaces of the capsule;* and the cessation of the motion when the otolites are removed proves them to be unciliated themselves, and, at the same time, distinguishes the motion from that of inorganic molecules as described by Mr. Brown.†

And in these discoveries you have a lively example of the nicety of anatomical researches in our times. In my student days, it was questioned whether any mollusk besides the cuttles had eyes;‡ and it was agreed on all hands that they were earless and surd.§ Behold the change a few years has made in our knowledge of this branch of physiology! They have eyes and they see; and ears have they, yet, from the very rudimentary condition of the organ, it is adapted to communicate to the possessors only the most limited perception of sonorous undulations. Amusing myself with

* "Kölliker has observed, that the motion of the otolites in the mollusca is dependent upon cilia, with which the internal surface of the cyst is covered."—*Reports on Zoology* for 1843-4, printed for the Ray Society, p. 216.

† Observations sur l'Organe Auditif des Mollusques, par C. Th. V. Siebold, in Ann. des Sc. Nat. (1843), xix. p. 193—211.

‡ "Vermium genus omne oculis caret; Plin. nisi forte Sepia ejusque Cymbium. Limaces videntur etiam oculis instructi, modo veri sint oculi, a nostris certe diversi."—Linn. *Syst. Nat.* 1069.

§ "None of the mollusca appear to possess, even in the smallest degree, the sense of hearing, if we except the highly organized Cephalopoda."—Roget's *Bridgew. Treat.* ii. 436.

some experiments, I found that Snails (Helix nemoralis) are not affected by loud and harsh noises about them; nor are the Periwinkle and Whelk (Purpura lapillus) more susceptible in this respect. It is affirmed, however, by the Rev. L. Guilding, that the Strombidæ possess the sense of hearing, or something allied to it. "I lately suspended," he says, "a number of large Strombi by the spire, that the animal, when dead, might fall from the shell. They had remained in this situation several days, till the body, weak and emaciated, hung down nearly a foot from the aperture, and the eyes had become dim. I found that even before my shadow could pass over them, they were aware of my presence, and endeavoured to withdraw into the shell. I then cut off the eyes, with the thick cartilaginous tentacula in which they were lodged, but the animals still continued to be sensible of my near approach, while hanging in this mutilated and painful condition."* The experiment is not conclusive, nor does it appear indeed that any noise was made. The impression which gave the alarm might perhaps be from the pulses of the atmosphere, thrown into motion by the approach of the experimenter, and acting on a skin morbidly sensible. On a summer evening I have observed the common Spout-fish (Solen siliqua), extended along the surface of the fine sand in which they burrow, enjoying apparently the calmness and mildness of the season, take alarm and instantaneously descend when I was yet distant several yards: and I can explain this and similar facts only on the supposition of the existence of a sense of touch feelingly alive to impressions impalpable to our grosser sense. "In the case of many animals," says Müller, "it may be doubted whether they really hear at all: for every reaction of nerves under the influence of vibrations cannot be called the sensation of sound, since the sense of touch is capable of perceiving the same vibrations as a tremor."†

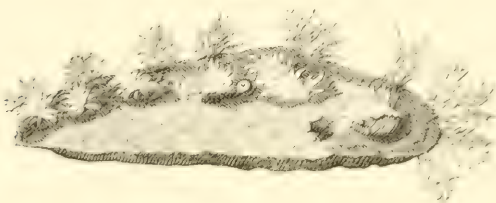
Thus we explain the fear which was anciently ascribed to the pearl-mussels during the thunderstorm, when they were so shaken "with the feare of flashie lightenings," that they cast their pearls and became "emptie;" and thus, also, we explain a fact mentioned by Baster, who, on the authority of the seamen engaged in carrying mussels to Holland, tells us that these shell-fish are grievously affected by any violent motion and concussion of the air; for if the ship is overtaken by a thunderstorm, or sails too near any other vessel which at the moment discharges its guns, the mussels,

* Zool. Journ. iv. 172. † Physiology, trans. p. 1129.

frightened with the tremor, shut their valves too suddenly, so as to expel the contained fluid, and in consequence soon die.*

Molluscous animals are dumb. There are a very few exceptions. "The noise made by the cuttle-fish, when dragged out of the water, resembles the grunting of a hog." † Two nudibranchial Gasteropods have been discovered to produce a sound, viz. the Tritonia arborescens and the beautiful Eolis punctata.‡ The sounds (Fig. 35)

Fig. 35.



which the former species produces, when in a glass vessel, says Professor Grant, "resemble very much the clink of a steel wire on the side of the jar, one stroke only being given at a time, and repeated at intervals of a minute or two: when placed in a large basin of water the sound is much obscured, and is like that of a watch, one stroke being repeated as before at intervals. The sound is longest and oftenest repeated when the Tritoniæ are lively and moving about, and is not heard when they are cold and without any motion; in the dark I have not observed any light emitted at the time of the stroke; no globule of air escapes to the surface of the water, nor is any ripple produced on the surface at the instant of the stroke; the sound, when in a glass vessel, is mellow and distinct." The Professor has kept these Tritoniæ alive in his room for a month, and, during the whole period of their confinement, they have continued to produce the sounds, with very little diminution of their original intensity. In a still apartment they are audible at the distance of twelve feet. "The sounds obviously proceed from the mouth of the animal; and at the instant of the stroke we observe the lips suddenly separate, as if to allow the water to rush into a small vacuum formed within. As these animals are hermaphrodites, re-

* Opusc. Subsec. i. 169. † Barbut Gen. Verm. 73.
‡ Alder and Hancock Nudibr. Moll. fam. 3, pl. 12.

quiring mutual impregnation, the sounds may possibly be a means of communication between them; or, if they be of an electric nature, they may be a means of defending from foreign enemies one of the most delicate, defenceless, and beautiful Gasteropods that inhabit the deep." *

You must not confound these sounds of the Tritonia and Eolis with what has been absurdly called the "music of snails," a noise created by the crawling of them on a moist window-pane of glass.† This is mechanical, and has no connection with the animal. As the source of the noise is often unsuspected, and as it is heard only in the evening after the dew has fallen, or at the witching hour of night, it has caused on some occasions a superstitious dread, and has afforded the ingenious Mrs. Bowdich a foundation for an interesting tale.

* Edinb. Phil. Journ. xiv. 186.

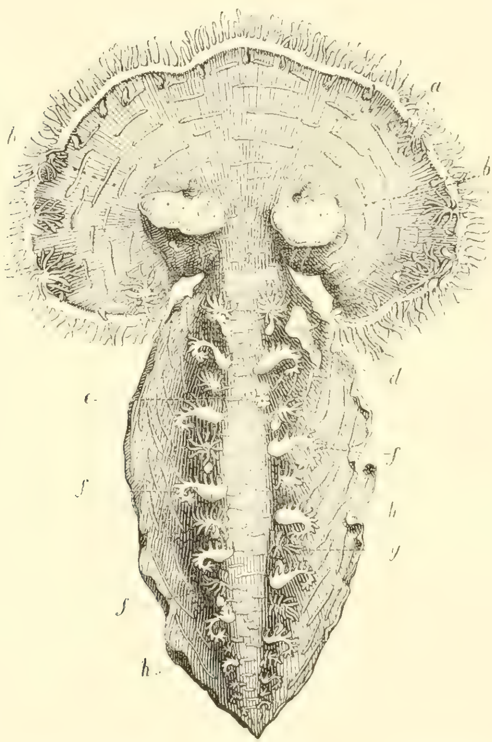
† Mag. Nat. Hist. n. s. i. 107.

LETTER XIII.

ON THEIR CIRCULATING SYSTEM.

Aristotle divides animals into those which have blood, and those which have none; and these primary classes were appropriately named the sanguineous and exsanguineous.

Fig. 36.



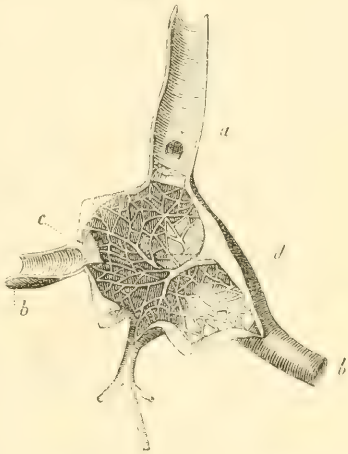
a, Veil; *b*, tentacula; *c*, neck; *d*, organs of generation; *e*, anus and another excretory orifice; *f*, greater branchiæ; *g*, lesser branchiæ; *h*, margins of foot.

Among the latter, he places the mollusca, as all naturalists did for a long time afterwards, and as all, except naturalists,

continue to do. Blood is scarcely known to the vulgar, unless by its red colour; and so essential is this character deemed, that it appears to them little less than an abuse of language to apply the term to any white or colourless fluid. Even Linnæus seems to have participated of this prejudice, and to have yielded to its influence, when he called the circulating fluid of the mollusca a *sanies:* but to call it anything else than blood is apt to lead into error; for it possesses all the essential properties of blood, flows in an analogous circle of vessels, and answers the same purposes in the system.

The circulating system of the mollusca consists of a heart, either single, or with its parts disjoined; and of two kinds of vessels, viz., arteries and veins: and the latter are supposed to perform the additional function of absorbents, for nothing analogous to these has been yet detected. The heart is very various in point of figure, but is always evidently muscular, and has its interior strengthened with fleshy cords (columnæ carneæ), interlaced in every direction (Fig. 37).* It is placed in general in the back, above the alimentary canal, near to or between the branchiæ, and in a cavity usually called the pericardium, and considered, according to Blainville erroneously,† as the representative of the same sac in the vertebrate animals.

Fig. 37.



The arteries are very elastic, and probably muscular, although no fibres can be detected in their gelatinous structure; their coats are thicker and stronger than those of the veins, which, indeed, are so extremely thin as frequently scarce to be distinguished from the tissues in which they

* Interior view of the heart of Octopus vulgaris, from Cuvier. *a*, The aorta; *b*, branchial veins; *c*, the valves; *d*, columnæ carneæ.

† Manuel de Malacologie, 131. "In the invertebrate animals, the heart and principal artery are generally placed on the upper part of the body, above the alimentary canal and largest portions of the nervous system; while in all vertebrate animals the order is reversed, the brain and spinal marrow being above, the heart below, the alimentary canal."—Thomson in *Cyclop. Anat. and Phy.* i. 648.

run. The veins do not appear to be provided with valves, as you know the veins of other animals are; but valves are placed at the orifices between the cavities of the heart, and very often at the entrances into the primary arterial and venous trunks.

With regard to the distribution of the sanguiferous vessels, it will be necessary to give a sketch of it in the principal orders separately; for it is subject to such important and considerable modifications, that there would be great difficulty in giving an intelligible view which would be applicable to molluscous animals as a whole. We may, however, observe, that, in all, the arterial blood issuing from the heart (or hearts, where this organ is double) is distributed through the body by the medium of the arteries, and returned towards the centre by the veins, which have united there into one or a few trunks; whence, again, they diverge into numerous ramifications, to conduct the blood through the branchiæ or gills, to be brought back by a corresponding set of vessels to its point of departure. The circulation, therefore, is essentially the same as in the vertebrate animals; but there exists in the latter an arrangement of vessels of a very peculiar kind, for a circulation through the liver — the system, as it has been called, of the *vena portæ*, to which there is nothing comparable in the mollusca.*

In the naked Cephalopoda there are three hearts. The true systematic heart, marked *a* in the diagram annexed (Fig. 38), consists of a single cavity, and is situated towards the centre of the body, between the gills. By its action the blood is propelled directly into a large artery or aorta (*b*), and into two smaller vessels, to be distributed, by their joint ramifications, to every organ and point of the body. One of the small arteries comes off from the inferior surface, and is

* "In the greatest number of mollusks the circulation is completed nearly in the same manner as in fishes, with this difference, however, that the heart is *aortic* instead of being *pulmonary;* or, in other words, the heart, receiving the blood from the breathing organs, sends it directly throughout the body. The heart is usually composed of a ventricle, whence the arteries take their origin, and of one or of two auricles in communication with the vessels which bring the blood from the gills; such is the case in the snails and all other Gasteropods, in the oysters and other bivalves; but sometimes there is no auricle, when we find a kind of venous hearts altogether distinct from an aortic ventricle, and situated at the base of the organs of respiration. Such is the case in the Octopus, the Sepia, and other Cephalopods. However this may be, in all mollusca the arterial blood passes through the heart, thence is distributed to every organ and part of the body, and then trends back to the organs of respiration, wherein having been subjected to the influence of the air, it returns anew to the heart to recommence its constant circuit."—Milne-Edwards' *Elem. de Zool.* i. 50.

destined to supply the testicle or ovary; the other rises from the anterior surface, and supplies in part the gills, the sac, and more especially the intestines and chylopoietic viscera; but it is the aorta, issuing from the heart on the posterior side, which carries the great mass of blood through the system, to furnish new materials for its growth and secretions.

Fig. 38.

From the extreme branchlets of the arteries the blood flows on into the capillary extremities of the veins, and commences its return to the centre; for the small branches of the latter vessels converge and unite by frequent inosculations into larger ones, until they are collected into a few trunks. The veins of the feet and superior parts form ultimately two of these (*c*), which almost immediately coalesce into one greater (*d*); and this vessel, after descending through part of the viscera into the abdomen, and

receiving blood from various little tributaries, again divides into two branches (*e e*). Each branch is here joined by a vein (*o*) of a size equal to itself, and which has brought the blood from the abdominal viscera; and a little afterwards by another, from the cloak and the supports of the gills. When thus augmented they proceed to their termination in the lateral hearts, placed, one on each side, at the root of the branchiæ. These hearts (*f*) are called pulmonic; * they are rather cellular than fleshy in texture, moderately thick, of a blackish grey colour in some genera, pale red in others, and pitted internally with many little cavities communicating together. Two large valves are placed at the venous orifice to prevent regurgitation; but there is none at the orifice by which the blood enters the artery (*g*), whose function is to carry it forwards to the gills or branchiæ (*h*), where, circulating through the windings of their beautiful leaflets, it is purified, and thence returned by veins running in the reverse direction, and which open at last by a single trunk (*i*) into the systemic heart, again to run the same endless circuit. †

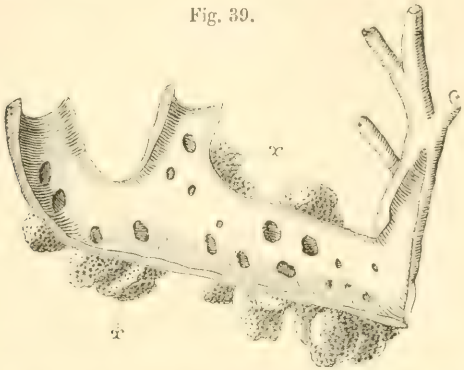
I have omitted in this description a very remarkable peculiarity connected with the venous system, and which merits our particular notice. Previously to their junction with the pulmonic hearts, the two branches into which the great dorsal vein bifurcates, and their accessory veins, pass across two large cavities, called *venous* by Cuvier, which communicate externally by an aperture on each side near the gills. In this part of their course the veins are garnished with some very singular glandular bodies (*x x*, Figs. 38, 39) of a spongy cellular structure, and yellow colour, from which an opaque yellowish mucous secretion can be easily pressed in considerable quantity. The cells of these bodies open freely into one another, and they have likewise a very free and direct communication with the interior of the veins to which they are appended (Fig. 39), but of their use it is difficult to form an opinion. Cuvier makes several suppositions: they may be, he says, diverticula, in which the venous blood is more fully exposed to the purifying influence of the circumfluent water; or they may be excretory canals, by which the spongy glands pour into the vein some substance which it could not of itself

* Lister mistook them for ovaries. Exer. Anat. tert. xxxiv.

† "The form of the systemic ventricle varies remarkably in the *naked* Cephalopods, as well as the direction in which it is extended; but there is great uniformity in the distribution of its vessels."—Grant in *Zool. Trans.* i. 83.

extract from that fluid; or, on the contrary, they may be emunctories, by means of which the blood is purged of some noxious principle. This last conjecture, he thinks,

Fig. 39.



is rendered more probable by the abundance of the yellowish mucus poured out; and it is certain that the communication between the interior of these bodies and the medium in which the animals live, is very open; for when air or an injection is thrown into the vein, the air or the injection passes very readily through the glands into the venous cavity, and thence outwards; or, on the contrary, if air is blown by its external orifice into this cavity, it passes thence very often into the veins.* "Were it practicable," says Dr. Fleming, "to analyse the yellow mucus which these glands contain, some light might be thrown on the subject: indeed, it appears not improbable that this arrangement is analogous in its functions to the urinary system in the most perfect classes." †

You will remark, that every use herein attributed to this apparatus is entirely conjectural, and although the following, thrown out by Mr. Owen, is of the same character, yet it is distinguished by a greater ingenuity and likelihood. He says, "In all the Cephalopods the follicles are appended to that part of the vascular system which terminates the greater, or commences the lesser circulation. But besides their use as connected with the respiratory system, and effecting changes in the blood itself, either by way of depuration or addition, I am induced to believe, from the following considerations, that they also perform a secondary function which has not hitherto been attributed to them.

* Mém. sur les Mollusques, i. 18, 19. † Phil. Zool. ii. 426.

"The Cephalopods of the higher order have a power of locomotion superior to all other mollusks, and can vary their elevation in the water at will. The Pearly Nautilus also, though in general dwelling in the deep, has the power of rising and floating on the surface, as appears from the testimony of Rumphius, and the circumstances connected with the capture of the present specimen. These changes of position must obviously produce great alterations in the degree of pressure which the animals have to sustain from the surrounding medium; and the fluids contained in their sanguiferous system must, of course, suffer considerable and corresponding variations of expansion. We must suppose also, that their respiration, or the transmission of the blood through the gills, will be more or less rapid, both according to the distance from the surface at which they breathe, and the degree of muscular effort that may at any time have been expended.

"In other classes of animals subject to the same mutations of surrounding pressure, various structures have been recognised as accommodating the sanguiferous system to these changes; as, for example, the extraordinary *rete mirabile* in the intercostal spaces of the Cetacea, and the varied muscular and elastic powers connected with the branchial artery of fish, which, according to Sir Everard Home, bear a relation to their powers of descending to great depths. The auricle also in fish, and the capacious venous sinuses which terminate in it, must afford convenient receptacles to the blood when in a state of expansion, or prevented by any cause from flowing freely through the gills; and the valvular structures for obviating the regurgitation of the contents of the ventricle into the auricle, or of the auricle into the sinus, are more complete in this than in any other class of vertebrate animals. But the branchial ventricle, in those Cephalopods which possess it, is unprovided with an auricle; and the Pearly Nautilus, if we except the follicles appended to the vessels passing to the gills, has no receptacle connected with the vascular system adapted to the uses above mentioned. I am therefore induced to believe that these follicles relieve the vascular system, by affording a temporary receptacle for the blood whenever it accumulates in the vessels, either from the effects of a general expansion, or of a partial impediment in its course through the respiratory organs, and that they serve to regulate the quantity of blood sent to these organs." *

* Memoir on the Pearly Nautilus, 33, 34.

The circulatory apparatus of the Gasteropods is less complex than that of the preceding order. They have a single heart, the position of which in the body is regulated by the position and symmetry of the branchiæ; for, in molluscous as in vertebrate animals, the heart is never far distant from the aërating organs. In the greater number of the Gasteropoda, it is situated in the back, above the intestinal canal, at an equal distance from each gill when this is paired, or obliquely to the left, and rarely to the right, when it is single. It is composed of an auricle and a ventricle: the former cavity is very variable in shape, and has very thin but muscular walls; the latter is equally variable, but, in general, of greater capacity, and more decidedly muscular. It is from one of the extremities of its great diameter that the arterial or centrifugal system proceeds; sometimes by a single trunk, or more commonly by two vessels. Of these, one is anterior, and the other posterior: the first furnishes branches to the head, to the gullet and adjacent organs; while the second sends its ramifications to the stomach, intestines, the liver, and the secretory organs of generation. The blood is brought back from these distant parts, as in other animals, by the venous, or, as it has been happily designated, the centripetal system; the numerous branchlets of which, after repeated inosculations, are at length united into one large trunk, which, generally without the intervention of any dilatation or auricle, assumes the character and office of a pulmonary artery, that again divides and subdivides itself, to conduct the circulating flood through all the sinuosities of the gills.

The description just given is liable to many exceptions, were we to descend to particular families and genera: and although, in a sketch of the kind I attempt to give you, it is impossible to notice all their peculiarities, yet it may be useful, and not void of interest, to select a few examples illustrative of the most remarkable anomalies in the arrangement of their circulating system. The Tethys leporina (Fig. 35), a native of the shores of the Balearic Isles, will afford our first instance. In this rare and beautiful creature, which seems to reside constantly in deep water, the heart is situated in the middle of the back, immediately under the skin. Its oval and very thin auricle receives the branchial veins, which trend towards it like the spokes of a wheel towards the nave, and pour into it the purified blood, not by one or two, but by numerous orifices. The opening from the auricle to the ventricle is furnished with two very distinct valves; and, as usual, the latter cavity

is more fleshy and opaque than the auricle, of an oval form, and strengthened with small muscular cords. Two principal arteries take their departure from it; one of which, proceeding forwards, gives branches to the stomach, œsophagus, to the organs of generation, to both sides of the back and foot, and lastly loses itself in the veil; while the other artery, directing its course backwards, is principally distributed on the rectum and liver. The veins issuing from this organ, and from the intestines, run in the sides of the body, where, in conjunction with the veins returning from the foot, the back, and the veil, they form ultimately two main vessels to carry the blood to the branchiæ; which are external, and arranged like crests, in two rows along the back, the principal ornaments of the animal.*

We may take our next example from among the terrestrial mollusca. The heart of the Slug (Limax ater) is placed almost in the middle of the pulmonary cavity, "included in an extremely thin bag or pericardium, in whose cavity there is abundance of watery moisture, as clear as the purest crystal." The auricle is of a triangular figure; the apex resting on the superior surface of the oval ventricle, and the much dilated base receiving the pulmonary veins, which, like those of the Tethys, open into it by many mouths. But the peculiarity most worthy of notice in this animal is the colour of its arteries,—an opaque and pure white, like what it would be were we to suppose them filled with milk, and rendered very obvious by the darkness of the ground upon which the vessels trace their course; as, for example, in the intestines, which are of a dark green; or in the liver, which is of a blackish brown colour. The finest injections do not produce anything, adds Cuvier, more agreeable to the eye of the anatomist than the white ramifications of the arteries in the Black Slug. †

The most singular deviations from the normal structure and disposition of the blood-vessels in the Gasteropoda are, however, to be found in the celebrated Aplysia. In this mollusk the great branchial vein receives the aërated blood from its little tributaries, which penetrate it in such a manner that their orifices form imperfect circles on the inner surface. The vein itself runs along the convex border of a crescent-shaped membrane, supporting the branchiæ, and opens, as usual, into the auricle; remarkable for size and the thinness of its parietes, which resemble fine gauze, the very slender fleshy filaments forming a pretty network.

* Cuv. Mollusq. vii. 11.

† Cuv. lib. cit. xi. 25.

The ventricle is oval, and its walls are also thin, although furnished with fleshy columns, crossed in every direction. The aperture between it and the auricle is provided with two valves, which hinder any reflux of blood. The aorta proceeding from the ventricle divides into two trunks; the first, trending directly to the left, pierces the pericardium, after a very short course, to enter the abdomen; the second returns at first towards the right, sends off a branch, and then leaves the pericardium also at its right side. The portion enclosed in this cavity has attached to it two crests composed of small vessels, which rise from the trunk itself, and again re-enter it, without affording the anatomist any clue whereby to guess the use of such a curious formation. It is always easy to inflate or inject these crests; and Cuvier hazards a conjecture that they may be secretory organs for the production of the liquid which fills the pericardium.

But a still more extraordinary peculiarity remains for our notice. The large vessel which carries forward the venous blood to the branchiæ, and which may be named either a vena cava or a branchial artery, since it fulfils the functions of both, after sending off arterial branches to the leaflets of the gills, remains for a certain space smooth and entire; but one part curves itself to the left, and another to the right, and these two branches assume suddenly a new form and structure; they become, in fact, absolutely confounded with the great general cavity of the body. Their walls are now formed of transverse and oblique muscular ribands, which cross in every direction, but leave between them apertures visible to the naked eye, and permeable to all sorts of injection; thus establishing a free communication between these vessels and the abdominal cavity, so that the fluids contained in the one can readily permeate into the other. This structure is so anomalous, that Cuvier was for some time doubtful of the accuracy of the dissections which seemed to prove it; but at last he fully satisfied himself, and ascertained distinctly that there was no other vessel to carry the blood to the branchiæ except the muscular and perforated cavities just described, and into which all the veins of the body open directly or indirectly. It follows, therefore, that the fluids shed into the abdomen can mix directly with the mass of blood, and be carried to the branchiæ with it; and that the veins perform the office of absorbent vessels. This vast communication, says the great naturalist from whom I borrow these anatomical details, is, doubtless, the first step to that still greater which nature has established in insects, where there is no parti-

cular vessels for the nutritive fluid; and we have already seen a trace of it in the Cephalopoda, where the venæ cavæ and the abdominal cavity communicate together through the medium of certain spongy glands.*

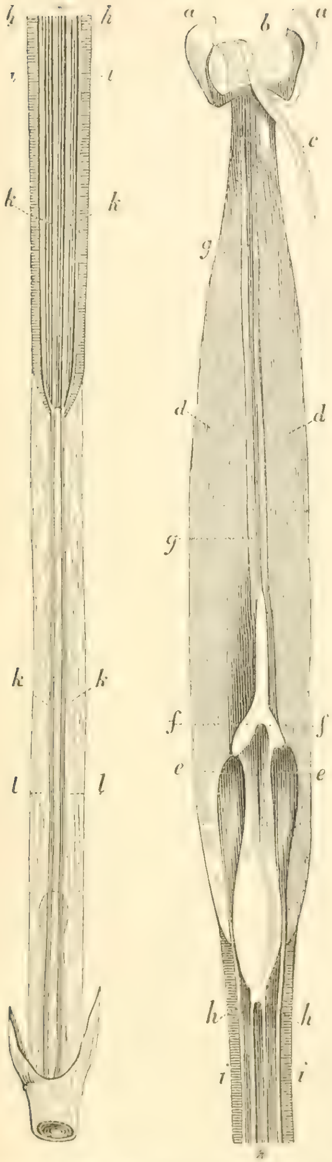
In the genus Onchidium, a naked mollusk, the venæ cavæ exhibit a formation in some respects similar to that in Aplysia; but I pass over this, to notice another sort of deviation from the common, in the Ear Shell (Haliotis), and in some simple univalves, as, for example, in Fissurella. The heart in these genera is provided with two auricles; one of which receives the vein carrying the purified blood from the right branchiæ, and the other that from the left. The auricles open into the ventricle, each by a single and generally narrow orifice; but in the Chitonidæ each auricle has two distinct and separated ventricular orifices; of which, according to Cuvier, there is no similar example to be found in the animal kingdom.† Further, in these genera the ventricle, or proper heart, is perforated by the straight gut, or, in other words, the heart encircles that intestine; a peculiarity not to be observed in other Gasteropoda.

What, however, is the exception and anomaly among Gasteropods, becomes the usual formation in the Conchifera or bivalved mollusca; for in by much the greater number of them the gut passes through the heart, or rather, as Blainville explains it, the heart is curved round the rectum, in such a manner that the two extremities of its transverse diameter seem to touch. The blood, collected from all parts of the body by the ramifications of the venous system, is poured by four principal trunks into a venous reservoir or auricle analogous to that which is found in the Sepia, and situated under the heart on the mesial line at the root of the branchial leaflets. From every point of this venous reservoir there depart a great number of vessels, which may be regarded as branchial arteries; and these, after having formed a considerable vascular net-work (increased by some veins composing, or only surrounding, a brown glandular organ on each side), proceed lastly to re-unite in the branchial longitudinal arteries which run along the back of the branchial lamellæ, and then subdivide there in the manner they do in every respiratory organ. It is from the extremities of these subdivisions of the branchial arteries, that the

* Mem. ix. 14.—Mr. Owen has found the same structure to exist in the Pearly Nautilus; and he suspects "that it may be more generally found on a further and more diligent investigation of the venous system in this remarkable class of animals."—*Memoir*, 28.

† Mem. xviii. 25.

Fig. 40.



veins of the same name begin; and, running in a contrary direction, they ultimately reach the large longitudinal veins into which they pour the refluent fluid. This enters into the two auricles, thence into the only ventricle, whence it is carried and distributed throughout the body by means of the arterial channels which lead away from that ventricle.*

As it offers some exceptions to this account of the distribution of the bloodvessels in the Conchifera in general, I am tempted to extract for you the interesting description of the circulation in Teredo navalis, as given by Sir Everard Home: — "The heart," he says, "is situated upon the back of the animal, near the head, consisting of two auricles (Fig. 40 †), of a thin, dark-coloured membrane; the auricles open by contracted valvular orifices into two white strong tubes; these, united,

* Journ. de Physique, lxxxix, 133. See also Garner in Charlesw. Mag. N. Hist. n. s. iii. 167.

† Figure of Teredo navalis, showing the heart and other internal organs, of the natural size, exposed in a posterior view. *a a*, The boring-shells, separated and turned back; *b*, the digastric muscle; *c*, the intestine passing over it; *d d*, the testicles; *e e*, the auricles of the heart; *f f*, the ventricle; *g g*, the artery going to the head; *h h*, the vessels from the branchiæ going to the heart; *i i*, the branchiæ or gills; *k k*, ducts of the testicles, traced through their course; *l l*, a strong substance, with transverse fibres, having a pile upon it, to strengthen this, the weakest part of the animal.

form the ventricle, which terminates in an artery that goes to the boring-shell. The heart is loosely attached; its action is distinctly seen through the external covering, and in some instances continued to act after it was laid bare.

"The first contraction is in the two auricles, which are shortened in that action. This enlarges the ventricle before it contracts. The great artery from the ventricle goes directly to the head, and the vessels that supply the auricles are seen to come from the gills. The auricles are lined with a black pigment, so that their contents cannot be seen through their coats, and the ventricle, from its thickness, is not transparent; but the muscles of the boring-shells are of a bright red, and all the parts between the heart and head are supplied with red blood."

In the Teredo, then, every part of the blood "passes through the vessels of the gills, and then through the cavities of the heart. As this animal is to work a machine capable of boring a very hard substance, and to go on working during the whole of that period of life in which its growth is continued, to make room for the increased bulk, so it requires that the blood be more highly aerated, and supplied with greater velocity to these active organs. The heart, also, to give it greater advantage in these respects, is placed near to the boring-shells, so that the blood which goes to them is of the brightest colour.

"In this circulation the first action of the heart is to supply the different parts of the body with aerated blood: upon this the activity of the heart is wholly exerted; the blood is returned more slowly through the gills, and remains there a longer time, so as to receive a greater degree of the influence from the air contained in the water."*

In the single Mollusca Tunicata the circulating apparatus is simpler than in any of the other orders. The heart of the Ascidia is an organ with a single cavity, situated near the stomach, † and presents a less distinct muscular structure than it does in cephalous mollusca. It is of an oblong or spindle shape, and the two extremities are prolonged into two vessels, almost equal to itself in their diameter.

* Lect. Comp. Anat. iii. 162, 163.

† According to Cuvier the position of the mouth determines the position of the heart; but according to Milne-Edwards, in all Tunicata the position is regulated by the situation of the ovaries. "Là où les ovaires sont thoraciques, le cœur l'est également; là où les ovaires sont logés avec le tube digestif dans un abdomen simple, le cœur est placé aussi à côté de l'intestin dans cette même cavité; enfin, là où l'ovaire est infère et se trouve dans un post-abdomen, le cœur est également relégué dans cette portion terminale du corps."—*Obs. Sur les Ascid. Comp.* p. 7.

One of these vessels receives, as it is believed, all the blood from the branchiæ, and is in consequence named the branchial vein; the other, of greater length, is an aorta to distribute the blood through the whole system.*

"In the Compound Ascidiæ, Mr. Lister has recently discovered one of the most remarkable modifications of the circulation with which we are acquainted. Mr. Lister finds that the different Ascidiæ of a branched animal are not only connected together by the polypiferous stem, but have a common circulation. In each individual there is a heart consisting of one cavity only, and pulsating about thirty or forty times in a minute. In the common stem, the motion of the globules of the blood indicates distinctly two currents running in opposite directions. One of the currents enters the Ascidia by its peduncle and proceeds directly to the heart; the blood issuing from the heart is propelled into the gills as well as the system at once, and upon its return from thence the returning current proceeds out of the animal by its peduncle again into the common stem, whence it goes to circulate through another of the Ascidiæ attached to the stem. The directions of the currents appeared to be reversed every two minutes or less. According to Mr. Lister, when one of the Ascidiæ is separated from the common stem, its circulation goes on in an independent manner, the blood returning from the body being conducted into the heart; but the alternation of the directions still continues,—a circumstance which points out an important difference between the Compound and the Simple Ascidiæ, in which last the circulating fluid is generally believed to pass from the gills into the heart, and to hold continually the same direction." †

These observations of Mr. Lister apply to the Social, and not to the Tunicata properly called Compound. Milne-Edwards discovered several notable peculiarities in the latter, the sum of which is, that the heart does not contract all at once, as it does in other animals, but in a manner which is comparable rather to the peristaltic motions of the intestines in the vertebrates. Beginning at one end of the heart, the contraction is propagated, in an undulatory manner, to the opposite extremity; and after a time, and a momentary pause, the order of the contraction is reversed, and the motion proceeds in the contrary direction. The flow of the blood obeys of course this alternate action in its moving

* Savigny Mém. sur les Anim. s. Vert. ii. 113.

† A. Thomson in Cyclop. Anat. and Phy. i. 650. Mr. Lister has given an account of his observations at greater length in the Phil. Trans. for 1834, p. 380.

power, and hence we have in these animalcules a circulation in vessels which are alternately arterial and venous,*— a fact, perhaps, that may find its parallel in the minute capillary system of the human body itself.

I have given you, in the preceding pages, the view of the circulation in mollusca such as I learned it principally from the "Mémoires" of Cuvier; but, within these few years, Milne-Edwards has shown that it needs to be qualified, and is, in some respects, erroneous. It is assumed, you will observe, that the blood circulates in closed tubes or vessels forming an uninterrupted system of conduits, — one set of vessels parting from the heart or central reservoir, and dividing into branches and smaller branchlets, which gradually lose themselves in the intimate texture of the organs. Here, it is also assumed, that they meet with, and are continued into other ramifications, equally fine, of a set of vessels which, returning from the organs, gradually coalesce into fewer and larger, until they at length constitute only one or a few trunks. There is no break in the continuity of the vessels, — no interruption to the circular current of the stream. Milne-Edwards' extensive researches lead to a different conclusion. He finds that in many mollusca, of all orders, a more or less considerable portion of the sanguiferous circle is always formed by lacunæ or interorganic gaps and gutters; that sometimes, in a considerable part of the body, there are neither arteries nor veins; while, in other instances, the arteries distribute the blood throughout the body to every portion where there is life to be supported, but there are no veins to ensure the return of the nutrient fluid, which, on the contrary, is shed into empty spaces between the different solid parts of the organism. Even in those mollusks in which the circulatory apparatus is most complete, and where there are veins as well as arteries, yet do these veins never form a continuous circle, but, on the contrary, the abdominal or peritoneal cavity becomes in part a sanguineous reservoir to interrupt it.* Milne-Edwards thus sums up the result of his numerous anatomies :—In no mollusk has there been found a closed system

* Obs. sur les Ascid. Comp. 7—9.

† "Chez les Mollusques, de même que chez les Crustacés, une portion plus ou moins considérable du cercle parcouru par le sang en mouvement est toujours constituée par les lacunes ou espaces interorganiques; jamais ce liquide ne se trouve emprisonné, comme on le supposait, dans un système clos et complet de vaisseaux à parois propres; quelquefois il n'existe, pour une portion considérable du corps, ni artères ni veines, d'autres fois les artères portent le sang partout où il y a vie à entretenir, mais il n'y a pas de veines pour assurer le retour du fluide nourricier qui s'epanche dans les la-

of bloodvessels. In the Bryozoa or Polyzoa, the initiatory class to the mollusca, there exist neither heart, arteries, nor veins, and the nutrient fluid is contained in the great visceral cavity in which the organs of digestion are suspended. In the molluscoid Tunicata there is a heart and a system of bloodvessels in the branchial portion of the body, but there are neither arteries nor veins in the visceral or abdominal portion, in which the circulation is through mazes and lacunæ of uncertain direction, and without any definable walls. In the bivalved mollusks the foot is divided into numerous small lacunæ or intervisceral interstices for the reception of the inflowing venous blood. On pushing a coloured injection into these intermuscular lacunæ, the fluid passes even into the vessels of the branchiæ and into the venous canals of the mantle. But in the mantle, as well as in the foot, there do not appear to be any veins properly so called, viz. tubes with distinct parietes to carry the blood from the tissues which this blood is to nourish to the heart or towards the appropriated organs of respiration. It is a system of lacunæ only which performs the functions of the network formed by the capillary vessels in the vertebrate animals; and these lacunæ, of almost microscopic size, open into other passages, which, from their disposition, much resemble veins properly so called, but are not so, for they have no walls independent of the adjacent parts. In the typical Gasteropods further progress is made towards a more perfect circulation, for now there are veins as well as arteries, but the former are still partially defective, and are represented, sometimes in the muscular system, and always in the space intervening between the principal viscera and the respiratory organ, by simple lacunæ or by the large visceral reservoir, into which the centripetal current flows by open orifices, and whence again it is carried by appropriate vessels to the branchiæ. For example: in the Snail the blood is distributed from the centre throughout every part of the body by the branching arterial system; and it is returned, partly by proper veins, and partly by mere lacunæ or gutters, to the large visceral cavity, into which it is emptied. The blood must consequently be here in contact

cunes comprises entre les diverses parties solides de l'organization; d'autres fois encore, l'appareil de la circulation se perfectionne davantage, car il existe des veines aussi bien que des artères dans une portion plus ou moins grande du corps; mais ces veines ne suffisent jamais pour compléter le cercle que le fluide nourricier doit parcourir, et la cavité abdominale ou péritonéale joue toujours le rôle d'un réservoir sanguin, aussi bien que d'une chambre viscerale."—MILNE-EDWARDS in *Annales des Sciences Naturelles,* ser. 3, iii. 280 (1845).

with the alimentary canal, but I find no mention made relative to its condition in this cavity,—whether stagnant or fluent, or how long it tarries there. It in some way, however, passes from it into other vessels, which have the office assigned them of subjecting this blood to the vivifying action of the air, and then to return it to the aortic heart or centre whence it started on its course. It is the same essentially in other Gasteropods. In the Cephalopods the venous system is still more perfected, yet without being made complete, for the visceral cavity continues to hold the place of a portion of the venous system. In the octopod Cephalopods the venous circulation is semi-lacunose in the abdomen as well as in the head; but in the Cephalopods with ten arms or tentacula, the system is entirely vascular in every part of the abdomen, and the lacunose portion of the circulating circle is found only in the head, where the blood is effused into a sinus containing the upper portion of the alimentary canal. Incompleteness then, or rather an interruption to the even and continuous flow of the blood in closed vessels in some part of its course, is the law with the mollusca, as it is, indeed, with the crustacea and invertebrate animals in general.* And this discovery, pronounced by Professor Owen to be the greatest made in the physiology of these animals of late years, reduces many of the so-called anomalous structures noticed in our previous review to the normal rule. They are reservoirs into which the veins open by wide and unvalved apertures, and pour the refluent blood. The aquiferous system of Delle Chiaje is of the same character, and forms the lacunose portion of the venous circle.† But while we may admit this, I must at the same time guard against your rejection of the office assigned to this organization in my letter on the aquiferous system, for the turgescence of the body, or its members, from the filling of the canals whether from without by water, or from within by blood, must exert the same influence over locomotion. In the case of the Gasteropods,

* Thus every thing concurs to prove the existence of a semi-vascular, semi-lacunose circulation in the mollusca, as well as in the crustacea and arachnides ; and if we wished to express by a general formula all the facts already ascertained that prove it, we might say that in all animals with white blood, the nutrient fluids are not enclosed in a closed vascular apparatus, but circulate more or less rapidly in a system of cavities formed in whole or in part by the interstices which are left between the different organs. Milne-Edwards, *Ann. des Sc. Nat.* (1845), iii. 314.

† Recherches Zoologiques faites pendant un Voyage sur les Côtes de la Sicile, par M. Milne-Edwards.—Observations sur la Circulation. Ann. des Sc. Nat. 3 ser. iii. (1845) p. 257. Nouvelles Observations sur la Constitution de l'Appareil circulatoire chez les Mollusques ; par MM. Milne-

where the blood effused into the visceral cavity, is in contact with and, as it were, bathes the alimentary canal, there may be a transference of chyle from it directly into the blood, and a similar transference of the aqueous portion of this into the intestine,—an exchange regulated by the well-known law of endosmose,—yet I cannot but think that many doubts may dwell reasonably over this part of their physiology.

You will observe that the reservoirs or lacunæ hitherto mentioned, which interrupt the circulation, receive only venous blood, but in the Haliotis and Patella, this degradation in structure reaches the arterial system also. In them, and in the genera allied to them, the aorta having reached the point at which the digestive canal is bent back, on the superior aspect of the pharynx, to descend into the abdominal cavity, opens direct into a vast cavity or lacuna containing the fleshy mass of the mouth, the salivary glands, and the cerebral ganglia, which are consequently surrounded by and bathed with the arterial blood. From this reservoir the blood is afterwards sent to the foot and to the appendages of the head. What is still more singular, the aorta in these animals fulfils functions analogous to those of the abdominal cavity, for, in the Haliotis, it actually contains within its tube the superior portion of the digestive organs; and, in the Patella, the membranous sheath of the base of the tongue receives the arterial blood; and from it the whole of the arterial system can be injected. M. de Quatrefages asserts, that he has found a similar deficiency of the arterial system in some species of Eolidæ.

These views of Milne-Edwards have been confirmed to a greater or less extent by Valenciennes, Owen, E. Blanchard, Nordman, M. de Quatrefages, and others, and must be received as in general correct. The accuracy of their full application to the Nudibranchia has been questioned by two most competent anatomists, Messrs. Hancock and Embleton. We shall have a future opportunity of mentioning some views relating to the circulation in this tribe, by M. de

Edwards et Valenciennes. Ibid. p. 307. — Lettre sur l'Appareil de la Circulation chez les Mollusques de la Classe des Brachiopodes; adressée à M. Milne-Edwards par M. R. Owen. Ibid. p. 315.—De l'Appareil circulatoire du Poulpe, par M. Milne-Edwards, Ibid. p. 341.—Mémoire sur la Dégradation des Organes de la Circulation chez les Patelles et les Haliotides, par M. Milne-Edwards.—Ibid. viii. (1847), p. 37. De l'Appareil circulatoire du Calmar. — Ibid., p. 53. — De l'Appareil circulatoire de l'Aplysie, Ibid. p. 59. De l'Appareil circulatoire des Thèthys, Ibid. p. 64.—De l'Appareil circulatoire du Colimaçon, p. 71.—Système circulatoire du Triton, Ibid. p. 75.—De l'Appareil circulatoire de la Pinine marine, Ibid. p. 77.

Quatrefages, now known to be erroneous; but Milne-Edwards asserts that the great veins do even in them terminate in a large venous reservoir or lacuna situated in the back, and constituting the great visceral cavity. The Nudibranchia form, according to him, no exception to his law. In the Thethys and the Eolides the circulation is not only incomplete, but there appear to be few or no proper veins to bring back the blood from the different organs to the branchiæ, and a system of more or less elongated channels takes their place. The abdominal cavity is a venous reservoir; and only in the track followed by the arterial blood do we find true vessels, viz., membranous tubes with parietes independent of the adjacent parts. Should we employ in the description of the mollusca the nomenclature of human anatomy, the enunciation of these results might seem erroneous, for we should then say that the Thethys, the Eolides, and the Aplysia were provided with veins, for they do possess branchio-cardiac vessels corresponding physiologically to the vessels that carry the arterial blood from the lungs to the heart, and which, in man, are called pulmonary veins; but as this nomenclature gives a false idea, it is better to limit the name of venous to that portion of the circulating system only which contains the venous blood. The vascular system, then, is incomplete; branchio-cardiac vessels conduct the arterial blood from the organs of respiration to the heart; arteries, properly so called, distribute the fluid to every part and organ of the body, and thenceforward it is essentially by the media of lacunæ or interorganic spaces that the venous blood flows back through the system and gains its goal in the branchiæ.

With much of this the elaborate dissections of Messrs. Hancock and Embleton disagree. They say,—"The branchio-cardiac sinus figured and described by Milne-Edwards, appears to us to be somewhat anomalous, and certainly differs from anything we have seen either in Eolis or Doris, and is quite at variance with the corresponding part in the Tritoniadæ, of which family it (Thethys) is clearly a member, for in Tritonia hombergii and in Scyllæa pelagica, the auricle is not longitudinally but transversely placed, receiving veins from the skin at each end." In Eolis there is a simple two-chambered heart, the blood coming from veins into the auricle, passing then into the ventricle, and being thence propelled along the arteries which carry the blood to the viscera and skin. How the arteries terminate is yet undetermined:—"We cannot undertake to say whether they end by closed extremities, or whether they have open mouths which communi-

cate with lacunæ or sinuses in the intervisceral spaces, or with those in the skin." But the veins communicate with, and originate from, a system of small sinuses forming a network which pervades the whole of the skin, "being abundant on the sides under the bases of the papillæ, and on the foot, and we suppose communicates freely with the system of intervisceral lacunæ pointed out by Milne-Edwards." "The general course of the blood will be necessarily then from the ventricle along the arteries to the viscera and to the skin; in the first case it passes from the arteries in a way we do not understand, into the lacunæ among the viscera and between them and the skin, and thence into the network of sinuses in the skin itself, in the latter case into the tegumentary sinuses; in them, and in the papillæ, into which it is freely admitted, it is more or less perfectly aerated, and thence flows into the veins which pass from the skin to the auricle, and which are called by M. Milne-Edwards branchio-cardiac vessels. From what we have observed, however, on attentively examining the connections of the ovarium, we are inclined to think that the whole of the blood does not circulate in the way above described, for we are pretty sure we have recognised small veins passing away from the sides of the ovarium and entering the skin, and we mentioned above that we had, though indistinctly, made out a pair of veins running from the same organ to the posterior trunk vein, that empties itself into the auricle. If these observations be correct, then a small portion of blood is returned to the heart in a way that forms an exception to the general rules, and the existence of veins distinct from the branchio-cardiac is established."*

The heart has been seen pulsating in several mollusks whose bodies possess the requisite degree of transparency that exposes the internal viscera to our gaze. The pulsations are usually slow, and often at unequal intervals, but this irregularity is dependent on the state of the animal in relation to action or repose, or it may be the effect of weakness or of pain, for generally the individual must be placed in an unnatural position, or removed from its proper element, before the observations can be made; and an attention to this circumstance may explain the fact of a retrograde motion of the circulating fluid, which has been observed by some experimentalists. Lister found that the heart, when removed from the Snail, ceased to pulsate after some hours, but being moistened with saliva, the pulsations were renewed; and this

* Ann. and Mag. N. Hist. sec. 2, i. 97—103.

happened even after twelve hours had elapsed from the exsection. The heart, in another experiment, being exposed and laid naked to the eye, was observed to beat spontaneously for a few seconds, then to stop for about the space of a quarter of an hour, when it again began to beat quickly and violently without any obvious cause, so that this learned physician thinks it certain that, in these animals, the motion of the heart is not beyond its control, but also voluntary or subject to the will,*— an inference in which you will not be disposed to coincide. In a small Snail just hatched, Bradley counted about three seconds between each pulsation; and in an old Snail from six to seven seconds elapsed.† Gaspard saw the heart of a Vineyard Snail (Helix pomatia) beating, in the summer, twenty-five to twenty-eight times in a minute; and that of a Pond-mussel contracted, according to Pfeiffer, fifteen times in the minute.‡ On examining a specimen of Carychium lineatum our mutual friend, Mr. Alder, observed, through the transparent shell, that its heart beat only eight times in a minute, and he was about to conclude that the slowness of locomotion, in this class of animals, resulted from the tardy circulation of the blood, when, on examining a few specimens of Vitrina pellucida, he was surprised to find that their heart beat about a hundred and twenty times in a minute! The latter was in a state of action, and the former of rest. He has since found, that the number of pulsations in the same individual is very unequal at different times,—a variableness dependent on external influences, doubtless, and principally, perhaps, on the temperature of the air or water to which the animals are exposed. §

The blood itself is of a bluish-white colour, and glutinous consistence.|| Lister tells us, that when he kept the

* Exer. Anat. de Coch. p. 38. Exer. Anat. tert. p. 13.

† Phil. Ac. of the Works of Nature, p. 129.

‡ Tiedemann's Comp. Phys. i. 156.

§ Mr. Garner states that in the Lamellibranchiata the pulsations of the heart are generally from twenty to thirty in the minute.—*Charlesw. Mag. N. Hist.* iii. 168. Messrs. Alder & Hancock have given the number of pulsations in the following Nudibranchiata:

Polycera ocellata	72—88	Ancula cristata	72—75
Doto coronata	60	Polycera lessonii	62
Eolis coronata	65	Hermæa dendritica	96
Eolis papillosa	50		

|| Sir E. Home says that the blood of the Teredines is red, *Comp. Anat.* i. 32; and that of the Planorbis is almost purple.—Milne-Edwards, *Elem. de Zool.* p. 18. Milne-Edwards has found, in the neighbourhood of Palermo, an Ascidia with red blood.—*Ann. and Mag. N. Hist.* xv. 69.

blood of a Snail in a vessel for some days, it remained liquid and entire, not separating, in the manner of human blood, into two portions of unequal densities; but, when he applied heat, it readily congealed into an opaque bluish coagulum, just as the human serum would have done under the same circumstances. But Lister knew well that the blood of these creatures was not homogeneous; for he adds, that with a good microscope it is easily shown to consist of globules swimming in a limpid fluid; that these globules are truly round, and considerably exceed in size those of human blood; they are also heavier than the fluid part, since they gradually sink to the bottom when kept still in a glass tube.* The late experiments of Prevost and Dumas have confirmed those of the old English naturalist: they have ascertained that the globules of the Snail have a diameter one third greater than those of man † and quadrupeds; and, what is more remarkable, they found the globules to be really spherical, as Lister has asserted, although analogy would have led us to a different conclusion; for they are elliptical in birds, reptiles, and fishes, to which the mollusca are certainly more nearly allied than they are to the mammalia. ‡ The globules in the bivalve mollusca are also, according to Poli, much larger than in man; so that he considers the latter to be to the former as hemp-seed to millet-seed. § The red colour of blood has been attributed to the

* Exer. Anat. de Coch. p. 95, and Exer. Anat. tert. p. xxxiii.—"Si tamen in bono microscopio examinetur, id est, syphone capillari vitreo, venæ alicui intruso, globulos opacos verè orbiculares haud paucos videbis; ac sanguineos nostros globulos magnitudine plurimùm excedentes. Hi vero globuli, ut præ sanguinis globulis pauci sunt, ita aqua quædam limpida innatant, et paulatim præ gravitate ad imum syphonem descendunt. Idem quoque experimentum de succo vitali in Cochleis fluviatilibus feci; idemque coagulum subcœruleum, igni admotus, dedit."

† The red globules of human blood, according to the observations of Mr. Bauer, as corrected by Kater and others, are one five-thousandth part of an inch in diameter.—Home's *Comp. Anat.* vol. iii. p. 4., compared with p. 12. But in the fœtus, the globules, say Prevost and Dumas, differ in their form and volume from those of the adult; the former being double the size of the latter. Bostock's *Physiology*, vol. ii. p. 200; and approximating nearer, of course, to the size of those of mollusca. The fact is curious, when considered in relation to some speculations of Carus.

‡ Zoological Journal, i. 178.

§ Rudolphi's Physiology, trans. i. p. 132.—Mr. Lister found the particles of blood in the Ascidiæ to be not uniform in size or shape, but they were mostly between ·00025 and ·0002 inch in diameter, and approaching to globular.—*Phil. Trans.* for 1834, p. 380. Milne-Edwards says that the blood-globules of invertebrated animals differ greatly from those of the vertebrated: their size is very variable in the same individual, their surface appears wrinkled, neither a central nucleus nor an exterior envelope can be distinguished, and their form is in general spherical.—*Elém. de Zoologie*, p. 21.

existence of iron in it in combination with phosphoric acid; but it perhaps militates against this hypothesis when we find that the white blood of the mollusca, although the contrary has been asserted, contains the same mineral ingredients; for Erman has detected iron, and very probably also manganese, in the blood of the Helix pomatia and Planorbis corneus; and Poli likewise speaks of iron in the blood of Arca glycymeris.* As the following analysis may probably be applied with safety to the whole class, I extract the passage entire, notwithstanding it repeats some particulars already noticed:—"The blood of the Helix pomatia," says M. Gaspard, "is rather thick, but without viscosity; it has a faint smell, a slightly saline taste, and is so abundant that each individual contains not less than a drachm and a half. It is of a delicate blue colour, which is neither altered nor modified by change of aliment, by asphyxia, or by hybernation. It is miscible with water, but of greater specific gravity, and falls to the bottom in visible streaks or entire drops. When exposed to the atmosphere it does not spontaneously congeal, like that of vertebrated animals, but it separates by rest into two distinct fluids; the one blue, which swims at the top; the other colourless and opaque, remaining at the bottom of the vessel. In a few days it decomposes with fetor. It is unaltered by muriate of barytes and by alcohol; is simply discoloured by potash, and by vinegar and other weak acids: but acetate of lead, nitrate of silver, and, still more, nitrate of mercury, occasion a copious dense precipitate. Boiling water, sulphuric and nitric acid, coagulate it strongly, like albumen."†

* Rudolphi's Physiology by How, i. 113.
† Zool. Journal, i. 177.

LETTER XIV.

ON THEIR SECRETIONS.

This letter you may properly consider as a continuation of the preceding; for the blood is the material out of which not only the growth and repairs of animal bodies, but likewise all the secretions, are directly derived,—the latter obtaining their peculiar properties from differences in the structure and action of the various glands or vessels through which they percolate.

1. Shell.—The most important and general secretion of molluscous animals is *shell*, but as the structure and formation of this must occupy a separate letter, I will at present confine myself to some account of its chemical composition, with such other remarks as may not find a more appropriate place in our correspondence.

However varied in external character, shells differ very little in their chemical composition. They all consist of carbonate of lime united to a soft albuminous matter, and any variation that occurs in different shells is merely in the relative proportions of these constituent parts. Mr. Hatchett, to whom we are indebted for all our correct information on this subject, has divided shells into two classes, according to the proportion and state of their animal matter. The first class he names Porcellaneous Shells, since they resemble porcelain, are usually of a compact texture, and have an enamelled surface, which is often finely variegated. The convolute shells afford good examples of this class. They consist of carbonate of lime, cemented together by so small a portion of albumen, that, when immersed in a dilute acid, the shell is completely dissolved, and not a sensible trace of it left behind. "The shells belonging to the second class are usually covered with a strong epidermis, below which lies the shell in layers, and composed entirely of the substance well known by the name of mother-of-pearl. They have been distinguished by the name of Mother-of-pearl Shells." The fresh-water mussels, the oysters, the Haliotis, and pearly Turbines are examples of this class. "When immersed in acids they effervesce, at first strongly, but gradually more and more feebly, till

at last the emission of air-bubbles is scarcely perceptible. The acids take up only lime, and leave a number of thin membranous substances, which still retain the form of the shell." These membranes have the properties of coagulated albumen.* But the distinction between these two classes holds good only in extreme cases; for there are many shells which are intermediate, and stand on debatable ground. The compact bivalves dissolve in the menstruum entirely, as does also the Common Whelk (Buccinum undatum), but they are not properly porcellaneous; while the various land-snails leave an insoluble membrane, though they are not perlaceous shells.

Mr. Hatchett thought that he discovered some traces of phosphate of lime in the shell of the Common Garden-snail (Helix aspersa); but as he did not find any in that of the Helix hortensis, it may be doubted whether the presence of phosphate of lime should be considered as a chemical character of land-shells.† According to Raspail and Prevost bivalve shells, in the first periods of their growth, consist wholly, or nearly so, of this latter earth,—a discovery as inexplicable as it was unexpected.

It has been made a question from what source the animal obtains the earthy material of its shell. Some, considering the vastness of the quantity required, or rather eliminated, by the millions of testaceous mollusca now living, and that have lived through all ages, and the enormous extent of the formations that have resulted from the deposition of their remains, have been led to ascribe to the animal a power to produce or generate lime by some interior, though yet unknown process, regulated by the all-controlling influence of the living principle. In proof of the existence of such a power, they remind us that the proportion of lime contained in sea-water, or river-water, and in their food, is obviously too small to furnish all that is excreted; and moreover it has been ascertained that snails confined, so that during a whole summer they have had no access to any preparation of lime, yet did secrete and form very considerable portions of shell.‡ It is dif-

* Thomson's Chemistry, v. 554, 555. Edinb. 1807.

* Phil. Trans. abridg. xviii. 556.

‡ To the instances formerly given, I may add another, furnished by Sir John G. Dalyell. "I have seen snails which were kept months in water only, void very sensible excretions, and increase the size of their shells, though these continued uncommonly transparent, nor could the excretions be the remains of food in the stomach, for the snails had never ate; they were young, and I had bred them from the egg."—Spallanzani's *Tracts*, trans. i. xliii.

ficult, after reading some experiments of this kind, not to give our assent to the supposition that some portion of the lime had, indeed, been developed by the vital powers of the animal; but since a physiologist, distinguished for his philosophic caution, has laid it down as an axiom "that no organic agent has the power either of *creating* material elements, or of *changing* one such element into another,"* we must hesitate,—at least if we believe calcium to be an elementary body; for then the mollusks must apparently obtain it from without, extracting it by molecules from the food and ambient water, and making it, through the agency of their secreting organs, enter into new compositions and decompositions. They are thus greatly employed in preserving the due quality of our lakes, rivers, and seas, extracting from the water unceasingly those impure earthy additions which are as unceasingly made from the death and decomposition of successive generations of their own races and of the Crustacea, from the frittering down of corals and of rocks by storms, atmospherical influences, and the still more powerful workings of the sea, and by the attrition of running water on calcareous soils.† From such sources the water is impregnated with that calcareous earth which it is the ordered duty of these animals to remove; and this they do by reconsolidating it, and making it pass into new forms of every variety and beauty, as I shall afterwards explain.

2. PEARL is another calcareous secretion of molluscous animals deserving notice. It is secreted by the fish of bivalves;‡ and principally by such as inhabit shells of foliated structure, as Pearl-mussels (Meleagrina), sea and fresh-water mussels, oysters, the Pinnæ, &c. A pearl consists of carbonate of lime in the form of nacre, and animal matter, arranged in concentric layers around a nucleus, as it is well shown in our figure (Fig. 41), copied from a beautiful engraving appended to a paper of Sir E. Home's in the "Philosophical Transactions." Each layer is presumed, but I know not on what grounds, to be annual; so that a pearl must be of slow growth, and those

Fig. 41.

* Prout's Bridgew. Treatise, p. 431.

† On this subject see Zool. Journal, i. 96, 97. Bostock's Physiology, ii. 386. Good's Study of Medicine, ii. 31. Turner's Sac. Hist. of the World, i. 97.

‡ Pearls "are not confined, as has been asserted, to bivalve shells, though they are more frequent in them than in others."—BAIRD, *in Chambers's Miscellany*, No. 167, p. 10.

of large size can only be found in full-grown oysters. "It is the nacral lining of the central cell that produces the lustre peculiar to the pearl, which cannot be given to artificial ones." *

Probably from some vulgar observation, there early originated a fancy that pearls were produced on St. John's eve by drops of

"rain from the sky,
Which turns into pearls as it falls in the sea,"—

or from dew-drops congealed and petrified in the oyster's shell. Boethius thus states the theory:—"These (pearl-mussels) earlie in the morning, in the gentle, cleare, and calme aire, lift up their upper shelles and mouthes a little above the water, and there receive of the fine and pleasant breath or dew of heaven, and afterwards according to the measure and quantitie of this vitall force received, they first conceive, then swell, and finallie produce the pearle." This "elegant hypothesis," as a fair lady deems it, was evidently congenial to the age which gave it birth, for it grew and prospered until it found favour with many wise and learned men, and became so diffused and popular that the poets even ventured to make use of it, which they have often done very prettily.†

* Lect. Comp. Anatomy, v. 306, and Phil. Trans. 1826, p. 339.—The ancient opinions on the production of pearls are to be found in Rondelet Hist. des Poiss. ii. 40. The shells containing the best pearls are old, and have usually a wrinkled or corrugated appearance externally: hence we have in Shakspeare,—"Rich honesty dwells like a miser in a poor-house, as your pearl in your foul oyster."—*As You Like It*, act v. sc. 4.

† And as was to be anticipated with some variations, for sometimes the dew was made to fall only on the eve of St. John; and oftener it fell, in the shape of tears, from a mistress's or a maid's eye:

"See these pearls that long have slept;
These were tears by Naiads wept
For the loss of Marinal.
Tritons in the silver shell
Treasured them, till hard and white
As the teeth of Amphitrite."
Bridal of Triermain, iii. 26.

It is curious to read with what serious gravity Bohadtch discusses this fancy and its various modifications, which, of course, he disproves!—*De Anim. Mar.* p. 39. The disproval needs not to prevent us quoting the following lines from Miss Pardoe's "Romance of the Harem:"

"There was a bright and a sunny sky
Spread over a laughing land,
But one small vapour was floating by,
Where the wild wave kissed the strand;
And as it passed o'er the ocean-swell,
A rain-drop from the dark cloud fell.

Thus Drummond sings,—

"With open shells in seas, on heavenly dew,
A shining oyster lusciously doth feed;
And then the birth of that ethereal seed
Shows, when conceived, if skies look dark or blue:
Pearls then, are orient-framed, and fair in form,
If heavens in their conception do look clear;
But if they thunder, or do threat a storm,
They sadly dark and cloudy do appear."

And Filicaja, an Italian poet, has moralized the tale sweetly:—

THE PEARL.

"As from its sedgy bed the ocean-shell
Mounts to the surface, and the lucid dew
Drinks,—thus transmitting to its inmost cell
The fertile juice that rears the pearl to view,
Fountain of life! so mounts my soul to thee!
To drink the beams that from thy presence well,
And quench its thirst in that celestial sea.
But as the pearl, though in the shell it lies,
Springs from the light, fair daughter of the skies,
So are not mine these strains, though mine they seem;
'Tis thou inspir'st me—as I touch the theme,
Thou giv'st the accents sound—from thee alone they rise.*

But pearls, as Mr. Gray justly observes, are merely the internal nacred coat of the shell, which has been forced by some extraneous cause to assume a spherical form. They

"'Alas!' the limpid moisture sighed,
As it clave the yielding air;
'And must I perish in that salt tide,
And die unregarded there?
Hard is my fate to be thus riven
From my glorious place 'mid the blue of heaven!'

"Down, down it fell; but ere the tide
Touch'd the bright sand of the shore,
An oyster that thirsted, opened wide
Its pearl-encrusted door;
And by the soft breathing of the air,
The limpid drop was wafted there.

"Time passed—and then a fisher came,
And from that oyster drew
A precious prize, whose wondrous fame
Through many a region flew;
The rain-drop had become a gem,
To deck a monarch's diadem!"

* Translated by Dr. J. M. Good in his Trans. of the Book of Job, p. 377

are, therefore, not properly "the unhandsome excretion of an oyster," nor "a distemper in the creature that produces them," and cannot, under any view, be compared with calculi in the kidneys of man; * for, though accidental formations, and, of course, not always to be found in the shell-fish which are known usually to contain them, still they are the products of a regular secretion, applied, however, in an unusual way, either to avert harm or allay irritation. That in many instances they are formed by the oyster to protect itself against aggression, is evident; for, with a plug of this nacred and solid material it shuts out worms and other intruders which have perforated the softer shell, and are intent on making prey of the hapless inmate; and it was apparently the knowledge of this fact that suggested to Linnæus his method of producing pearls at pleasure, by puncturing the shell with a pointed wire. † But this explanation, it is obvious, accounts only for the origin of such pearls as are attached to the shell; while we know that the best and the greatest number, and, indeed, the only ones which can be strung, have no such attachment, and are formed in the body of the animal itself. "The small and middling pearls," says Sir Alexander Johnston, "are formed in the thickest part of the flesh of the oyster, near the union of the two shells; the large pearls almost loose in that part called the beard." ‡ Now, these may be the effect merely of an excess in the supply of calcareous matter, of which the oyster wishes to get rid; or they may be formed by an effusion of pearl, to cover some irritating and extraneous body. The reality of the latter theory is, perhaps, proved by a practice of the modern Chinese, who force a large coarse species of swan-mussel to make pearls, by throwing into its shell, when open, five or six minute mother-of-pearl beads strung on a thread: in the course of one year these are found covered with a crust which perfectly resembles the real pearl. § The extraneous body

* List. Hist. An. Ang. p. 150. Dr. Turton has adopted this notion of Lister's (Edit. Gmel. iv. 176); and the learned Mr. Turner, receiving it as a truth, infers, from the abundance of pearls in the mussels of the Conway, that the water of this river "had some quality or substance which gave the Mya a sickly tendency."—*Sac. Hist.* i. 303.

† Lin. Corresp. by Smith, ii. 429. Pearls formed somewhat in this manner, by the fresh-water mussel, are preserved in the Hunterian Museum.—Home's *Lect. Comp. Anat.* vi. 296. See also Edinb. Phil. Journ. xi. 40.

‡ Home's Comp. Anat. v. 308.

§ The Chinese appear to have more ways than one of getting artificial pearls. Sir E. Home says their method is this:—"They take the substance of the clamp-shell, turn it in a lathe into hemispheres of different sizes, and

which naturally serves for the nucleus appears to be very often, or, as Sir E. Home says, always, a blighted ovum. Christophorus Sandius, in 1673, on the authority of Henricus Arnoldi, "an ingenious and veracious person," asserted that the ova left unexpelled from the shell became the nuclei on which pearls, in the freshwater mussel, were formed. "Sometimes," he says, "it happens that one or two of these eggs stick fast to the sides of the matrix, and are not voided with the rest. These are fed by the oyster against her will; and they do grow, according to the length of time, into pearls of sufficient bigness, and imprint a mark both on the fish and the shell, by the situation, conform to its figure." This theory has been fully adopted by Sir E. Home, from whose paper I have made the above quotation.* "If," says this unworthy anatomist, "I shall prove that this, the richest jewel in a monarch's crown, which cannot be imitated by any art of man, either in the beauty of its form or the brilliancy and lustre produced by a central illuminated cell, is the abortive egg of an oyster enveloped in its own nacre, of which it receives annually a layer of increase during the life of the animal, who will not be struck with wonder and astonishment?" And, as proofs of this, he informs us that he has always found the seed-pearls in the ovarium, or connected with that part of the shell on which the ovarium lay; and he has discovered that all oriental pearls have a brilliant cell in the centre, of a size exactly large enough to contain one of the ova.

introduce them through the shell of the oyster, with the convex surface towards the animal; the prominent part is, consequently, covered with nacre, and annually receives an increase. By introducing hemispheres instead of spheres, they avoid irregularities on the opposite surface. In this manner half pearls are made, since they cannot make whole ones; and when these are set to represent pearls, they will pass off undiscovered by an inexperienced eye, but not by those who understand pearls, being deficient in lustre."—*Comp. Anat.* v. 296. Mr. Gray, however, has proved that this people introduce, for the same purpose, pieces of mother-of-pearl, and also portions of silver wire, bent into a peculiar form, between the mantle of the animal (while yet alive) and the shell; "for they could not have been put in through a hole in the shell, as there was not the slightest appearance of any injury near the situation of the pearls on the outer coat." Mr. Gray tried the experiment on our fresh-water mussels, by introducing pieces of mother-of-pearl between the mantle and the shell; but with the result I am not acquainted. He adds:—"If this plan succeed, which I have scarcely any doubt it will, we shall be able to produce any quantity of as fine pearls as can be procured from abroad." See Home's Lectures, v. 300, 301; Edinb. Phil. Journ. xiv. 199; Annals of Philosophy.

* The quotation varies a little from the text as printed by Forbes and Hanley, who spell the author's name Sardius; and his informant's name is made Arnoldt.—*Moll. Brit.* ii. 152.

"From these facts, I have been led to conclude that a pearl is formed upon the external surface of an ovum; which, having been blighted, does not pass with the others into the oviduct, but remains attached to its pedicle in the ovarium, and in the following season receives a coat of nacre at the same time that the internal surface of the shell receives its annual supply. This conclusion," he adds, "is verified by some pearls being spherical; others having a pyramidal form, from the pedicle having received a coat of nacre as well as the ovum." * This conclusion, however, is far from being true. I will not deny that the fact may be, in not a few instances, as stated by Sir E. Home, for the ovum may accidentally fall into a situation where it shall become a source of irritation like any other extraneous substance; but that this is often the case is contradicted by numerous observations, and by the true theory of the formation of pearls. Professor Baer, of Koenigsberg, aware of Home's theory, undertook an investigation of it in the freshwater mussels of Germany, and the result was, that he never met with pearls either in the ovaries, liver, kidney, or any of the internal organs. The pearls were always situated either in or under the skin of the back, where it is close to the shell. †

I shall conclude what I have to say concerning pearls with the following extract from the paper of Mr. Gray quoted in the preceding page:—"The pearls are usually of the colour of the part of the shell to which they are attached. I have observed them white, rose-coloured, purple, and black; and they are said to be sometimes of a green colour.‡ They have also been found of two colours; that is, white with a dark nucleus, which is occasioned by their being first formed on the dark margin of the shell before it is covered with the white and pearly coat of the disk, which, when it becomes extended over them and the margin, gives them that appearance.

"Pearls vary greatly in their transparency. The pink are the most transparent; and in this particular they agree with the internal coat of the shell from which they are

* Comp. Anat. v. 302; and Phil. Trans. 1826, p. 339.

† Edinb. New Phil. Journ. xiv. 186. There is a very interesting paper on the growth and structure of pearls in the Edinb. Phil. Journal, xi. 39, &c. See also Reaumur in Mém. de l'Acad. Roy. des Sciences, an. 1717, p. 243, &c.

‡ "There are, besides, [in Britain] several sorts of shellfish, among which are mussels, containing pearls often of the best kind, and of every colour; that is, red, purple, violet, green (prasini), but principally white, as we find in the Venerable Bede's Ecclesiastical History."—Richard of Cirencester, trans. p. 28.

formed; for these pearls are only formed on the Pinnæ, which internally are pink and semi-transparent, and the black and purple specimens are generally more or less opaque.

"Their lustre, which is derived from the reflection of the light from their peculiar surface produced by the curious disposition of their fibres, and from their semi-transparency and form, greatly depends on the uniformity of their texture and the colour of the concentric coats of which they are formed. That their lustre does depend on their radiating fibres, may be distinctly proved by the inequality of the lustre of the 'Colombian pearls,' which are filed out of the thick part near the hinge of the Pearl-oyster (Avicula margaritifera); so that they are formed, like that shell, of transverse laminæ, and they consequently exhibit a plate of lustre on one side which is usually flat, and are surrounded by brilliant concentric zones, which show the places of the other plates instead of the even, beautiful, soft lustre of the true pearls."

3. Colours.—The colouring of the shell is a part of the theory of its formation, which will be more fittingly discussed hereafter; but since their colours depend on the secretion of a peculiar matter in the mucous skin, this may be not an improper place to introduce some facts I have collected relative to the colours of the animal considered abstractedly, and which are principally intended to prove to you that there is not any strict correspondency between those of the tenant and its testaceous covering. Those parts of the body of the mollusk which are constantly covered are usually of a uniform white, a straw, or a greyish colour; and the dark spots with which they are clouded are almost always occasioned by the opacity of the internal viscera or their contents; but the organs extended beyond the shell, and which have felt the influence of the light, are very often vividly tinted and variegated; and you may deem it very probable that the intensity of the colours will be deepened or mitigated by the higher or lower latitude of the shore inhabited by even the same species. Our native Cowry (Cypræa europæa) is a plain white shell, but its snail is a very elegant creature. The proboscis is dark vermilion; the tentacula yellowish red, spotted with yellow; the upper part of the foot streaked longitudinally with yellow and brown; and the mantle greenish brown, edged with brownish red; but, notwithstanding, the shell is a uniform dull white. Similar discrepancies between the colour of the shell and its owner are often met with: thus,

the Cypræa voluta of Montagu (Marginella voluta, Fleming) has its fins or lateral expansions elegantly speckled with bright yellow, and the fleshy part of its body with pink.* The long proboscis of the Aporrhais pes-pelicani is pink, dotted over with milk-white spots; and the animal of the white Scalaria clathrus is mottled black and white. Mr. Collier says, of some tropical species, that the foot is "blackish red in the Murices generally; green in Strombus, and some species of Trochus; black in Bulla ovum; deep red with faint designs, like those of the shell, in Conus tulipa, marmoreus, and its varieties; spotted, in Buccinum harpa; bright yellow, in Buccinum cassis; mottled, in Oliva; and deep brown, from spots, in some species of Voluta."† The snail of the beautifully marbled Harp-shell (Harpa ventricosa, Lamarck) glories in a rich vermilion red skin. "In the Mauritius, it is the amusement of the place to watch over the trim apparatus of lines hung over some sand-bank to tempt the various brilliant species of Oliva which there abound, or to wait for the more rare approach of the harp-shell, till the rich hues of its inhabitant are seen glowing through the clear blue water in the rays of a tropical rising sun."‡ M. Rang has discovered that the animal of a species of Sigaretus, described in the Bulletin of the Linnæan Society of Bordeaux, changes its colour three or four times during its life,—a circumstance which may easily lead to error, by inducing observers to consider as distinct species what are merely varieties dependent upon age; and it appears that Sigaretus is not a solitary instance of such mutability among the Gasteropods.§

The colours of the naked mollusca are very various: there are black, white, grey, brown, yellow, red, and even green species; and the colours are sometimes uniform and single, but more commonly mixed, and disposed in freckles

* Montagu Test. Brit. p. 204.

† Edinb. Phil. Journ. Oct. 1829, p. 228. Mr. Collier uses the Linnæan names.

‡ Broderip in Zool. Journ. ii. 199. "L'animal des Tridacnes et des Hippopes offre de fort belles couleurs. Celui de la Tridacne safranée, décrit par MM. Quoy et Gaimard, est d'un superbe bleu de roi sur les bords, linéolé en travers de bleu de ciel; plus en dedans est une rangée de lunules d'un jaune verdâtre; le centre est d'un violet clair, avec des lignes longitudinales ponctuées de brun. On a sous les yeux l'un des plus charmants spectacles que l'on puisse voir, lorsque, par une petite profondeur, un grand nombre de ces animaux étalent le velouté de leurs brillantes couleurs, et varient les nuances de ces parterres sous-marins. Comme on n'aperçoit que leur ouverture bâillante, on ne peut pas se figurer ce que c'est au premier aspect." —Chenu *Trait. de Conchyl.* 87.

§ Edinb. Journ. of Nat. and Geogr. Science, i. 455.

or clouds. Cranchia bonnellii affords probably the most remarkable example of colouring in the class. This bizarre Cephalopod, whose form involuntarily reminds us of those fantastic beings with which the genius of Callot has peopled hell, and which the opera sometimes imitates in its marvellous scenery, appears to rival the butterflies of tropical suns in gaudiness and brilliancy. A broad membrane unites its six upper arms into a large veil of a very rich purple colour, adorned with six double rows of buttons of sapphire-stone formed by the cups or suckers. The ventral surface of the sac, of the head, and of the two inferior arms, is studded with yellow spots arranged in quincunx, and near each spot there is another, in relief, of blue. These yellow and blue spots lie on a reddish ground sprinkled with purple dots, and have such a lustre in the living animal that they resemble as many topazes, near each of which a sapphire has been mounted.* To dwell, however, on this subject would be useless; and I pass on to notice the very curious phenomena exhibited in the coloured spots of the Cephalopoda.

The surface of these remarkable creatures, particularly the back and sides, is speckled with numberless minute coloured dots, which vary in size, tint, and arrangement, in the different species; and in the same species are liable to change, in the same respects, according to their degree of developement. These dots are properly follicles, or little bladders, seated in the mucous web (rete mucosum), and consequently covered by the epidermis, which is smooth and transparent. "During life, when the animal is in a state of repose, the vesicles are contracted, and are not visible. When it is excited, by being touched with the hand, or otherwise irritated, the coloured vesicles show themselves and are instantly in motion, appearing and disappearing with the velocity of lightning: sometimes they are like spots on different parts of the body; and sometimes like waves, which rapidly move across its surface." These appearances are produced "by the rapid and simultaneous contraction which takes place in all the vesicles of a particular part of the body, and from the sudden and simultaneous expansion of all the vesicles on another part;" but the process may go on until the whole body is covered, and its natural colour become changed for that of the vesicles. Even long after death these vesicles may be made to exhibit the same alternate contractions and expansions on the application of slight irritation.

* Ann. des Sc. Nat. n. s. iii. 344.

Naturalists have been long acquainted in some degree with these singular phenomena. Pliny tells us that the cuttle-fish change their colour through fear,* adapting it, cameleon-like, to that of the place they are in; and some expedience-dogmatists have meanly recommended us to imitate their accommodating quality—

> "Apud homines cum eris, tibi in mentem veniat polypi,
> Ad saxa variari nativum colorem corporis."†

None of the older authors, however, attempted to investigate their cause; but, of late, several theories have been offered, and two of these are founded on a minute inquiry into the structure of the vesicles. Cuvier said, conjecturally, that the appearances were dependent on the effusion of a coloured fluid in the areolar tissue of the skin;‡ and Professor Grant refined upon this hypothesis, by supposing the fluid to pass repeatedly to and from the minute vesicles: § but this conjecture has been apparently disproved, for the spots have no connection with any vascular system, nor do the vesicles contain any encysted fluid. Dr. G. San Giovanni, of Naples, an intelligent comparative anatomist, offered

* Hist. Nat. ix. 46.

† Plutarch compares flatterers to the Polype. In his Orat. de Patient. et Tolerant., he says, "Nor must the wiles and fraud of the Polype be passed over in silence. To whatever rock it adheres it imitates and assumes its colour, and thus many fishes while swimming strike against the polype as against a rock, and become the prey of its craftiness. Similar in manner are those who always frequent the company of those who have power and command, and who so accommodate themselves to times and occasions, that they never remain permanently of one opinion, but carry themselves hither and thither and change their opinions at any one's will and pleasure." Clearchus's advice is,—

> "Polypi, mi fili, Amphilocles heros, mentem habe,
> Et ad quorum gentem veneris, te iis accommode."

‡ Mém. i. 7.

§ Edinb. New Phil. Journ., xvi. 313.—This opinion is also adopted by H. Milne-Edwards, who seems to rest it upon experiments which are certainly at variance with those of Dr. Coldstream. H. Milne-Edwards says, "The skin of these animals is furnished with a number of differently-coloured spots, which alternately appear and disappear; and if a portion is put under a microscope, it may be perceived that these changes depend on the contraction of small vesicles *filled with a coloured liquid*, which reach from the surface of the skin to a considerable depth. When one of these spots appears, the liquid corresponding here to the pigment in the other case is propelled towards the superficial part of the vesicle, and there displays itself; whilst during its disappearance it is forced into the deeper parts by the contraction of this superficial point itself, which then becomes almost invisible."—*Edinb. New Phil. Journ.* xvii. 319.

another explanation, founded on a connection between the vesicles and the nervous system, which he imagined he had traced. The colour is correctly stated to be inherent in the tissue itself; and its changes are attributed to the particular structure of the vesicles, each of which, he says, has a circular aperture that opens and shuts, probably by means of a circular muscle, the actions of which are regulated by the will of the animal, through the medium of the nerves, with which the vesicles are connected by means of delicate filaments, scarcely discernible even with the aid of a microscope. But the observations of Dr. Coldstream destroy this ingenious and plausible theory. Dr. Coldstream could not discover, by the most careful microscopic examination, the slightest trace of any nervous threads in connection with the vesicles; and he proved, which seems incompatible with their dependence on their nerves, that the vesicles possessed motion in pieces of the mucous coat which had been removed entirely from the body: nor could he succeed in discovering any opening in them, such as San Giovanni asserts they have, even during their greatest dilatation, and under the most favourable circumstances. "That I might ascertain," to use Dr. Coldstream's own words, "whether or not the motions of the spots were now (after apparent death had taken place) carried on by the influence of external agents, independently of any nervous power emanating from the animal itself, I cut, from a part of the mantle where the contractions and dilatations were very strong, a piece of the membrane or layer containing the spots, about two-tenths of an inch square; this I separated completely from the animal, and placed it in a watch-glass immersed in sea-water in another vessel. To my astonishment, I saw that the spots in the separated portion continued in as lively motion as when connected with the animal. No change, either in the velocity or extent of their motions, could be perceived. Some spots, just on the edges of the separated piece, seemed to have been half cut through by the scissors with which I removed it: such did not contract; but all the others in the piece moved in the very same manner as before.

"I now removed the watch-glass, containing the separated portion, to the stage of a microscope, and examined the spots with powers of 100 and 150. This, however, gave me no advantage; I saw nothing more than I had previously observed with the naked eye. San Giovanni has compared the appearance of the structure of the spots to that of felt; but I could not satisfy myself that this was the case in those examined, although I passed through the membrane a very

strong light. I saw that the spots were very thin bodies, attached to the mucous coat of the integument; that they had no connection with the epidermis; that, in dilating, their edges passed over or under each other indiscriminately; that their edges were extremely sharp and well defined; that they never were increased in thickness during dilatation; and that no vessels carrying coloured fluids entered them. I could not discover, indeed, any thing like either vessels or nervous filaments connected with any part of the integument of the animal; and I feel assured, that, from the great size of some of the spots which I had under the microscope, I must have seen at least a few vessels carrying dark-coloured fluids entering the mucous coat, had it been from such a source that the increase in size of the spots was derived.

"The separated piece of the mucous coat, with the palpitating spots, remained under my microscope, exposed to a strong reflected light, for three-quarters of an hour, during which time I could perceive no alteration in its appearance, or the strange phenomena it presented. While the motions of the spots were very brisk, I suddenly removed it to a dark place, where it remained fifteen minutes. On bringing it again to the light, I found that all motion had ceased; most of the spots were in a state of contraction; but, on allowing it to remain for three minutes exposed to a moderately strong light, the dilatations again commenced, and were carried on unceasingly for a very considerable time. I repeated these experiments with other pieces of the spotted membrane, and always with similar results. At the end of nearly two hours from the time when some of them were removed from the animal, the spots were dilating; but, in the course of a few minutes afterwards, motion finally ceased." *

4. Inky secretions.—It has been conjectured, that the

* Edinb. Journ. Nat. and Geogr. Science, ii. 296. The paper from which the above extract is taken contains the best account which has yet been published of these coloured vesicles, or "chromophorous globules," as they have been termed. The reader may also consult the Edinb. Phil. Journ. xi. 422. The Cypræa tigris possesses the same changeable property. "Mr. Samuel Stutchbury, who had an opportunity of examining many individuals of C. tigris at the Pearl Islands, informed me that those cowries lived there in very shallow water, and always under rolled masses of madrepore. They never were to be seen exposed to the sun's rays. On lifting one of those masses, a tiger cowry was generally observed with its shell entirely covered by the large mantle, which was mottled with dark colours, the intensity of which the animal seemed to have the power of changing; for the colours varied in the same light and in the same medium, after the manner of the spots on the cephalopodous mollusca, or, to use a more familiar instance, somewhat in the same way that the hues of a turkey-cock's wattle vary."—Broderip *in Zool. Journ.* iv. 163.

peculiar property in the skin of the Cephalopoda, just described, is given to them as a means of defence; and the conjecture seems to have been confirmed by some observations of Mr. Charles Darwin, which I shall transcribe for your perusal. When at St. Iago, he was much interested, on several occasions, by watching the habits of an octopus, common in the pools left by the retiring tide. These animals, he says, escape detection by their cameleon-like power of changing their colour. "They appear to vary the tints, according to the nature of the ground over which they pass: when in deep water, their general shade was brownish purple; but when placed on the land, or in shallow water, this dark tint changed into one of a yellowish green. The colour, examined more carefully, was a French grey, with numerous minute spots of bright yellow: the former of these varied in intensity; the latter entirely disappeared and appeared again by turns. These changes were effected in such a manner, that clouds, varying in tint between a hyacinth red and a chestnut brown, were continually passing over the body." "This cuttle-fish displayed its cameleon-like power both during the act of swimming, and whilst remaining stationary at the bottom. I was much amused by the various arts to escape detection used by one individual, which seemed fully aware that I was watching it. Remaining for a time motionless, it would then stealthily advance an inch or two, like a cat after a mouse; sometimes changing its colour: it thus proceeded, till having gained a deeper part, it darted away, leaving a dusky train of ink to hide the hole into which it had crawled."* The Cephalopods then would seem to be doubly armed; for, when in danger, they are well known to eject a copious black liquor through their funnel or excrementary canal, as a means of obscuring the circumfluent water, and concealing themselves from all foes:†—

> "Long as the craftie cuttle lieth sure
> In the blacke cloud of his thicke vomiture." ‡

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* Journal, iii. 6, 7.

† Arist. Hist. An. ix. 37. Couch's Cornish Fauna, p. 81.

‡ "The ink secreted in this bag has been said to be thrown out to conceal the animal from its pursuers; but, in a future lecture, I shall endeavour to show that this secretion is to answer a purpose in the animal economy connected with the functions of the intestines."—Home's *Comp. Anat.* i. 376. This opinion of Home's may seem to gain some support from an observation of Lister's, who found the intestines and cæcal appendages of a Loligo filled with the ink.—*Exer. Anat. tert.* p. xxx. Dr. Coldstream, in a letter to the author, detailing the manners of Octopus ventricosus in captivity, says, "I have never seen the ink ejected, however much the animal may have been irritated." M. d'Orbigny thinks it doubtful whether any of the Cephalo-

As the gods of Homer, says Plutarch, concealed their favourites in clouds, in order to protect them from their pursuers, the Sepia can do the same with its liquid. This liquid consists of a mass of extremely minute carbonaceous particles, intermixed with an animal gelatine or glue, and capable of being so widely spread, that an ounce of it will suffice to darken several thousand ounces of water.* It is secreted in a bag that lies near the liver, and sometimes even embosomed in it, and that communicates with the funnel by means of its own excretory duct.† The interior of the bag is not a simple cavity; it is filled with a soft cellular or spongy substance, in which the ink is diffused. This has no relation or analogy with bile, as Monro believed; but it is a peculiar secretion, somewhat glutinous, readily miscible with water, and variable in point of shade, according to the species of Cephalopod from which it comes. In every species of the class the tint of the secretion corresponds, more or less, with the coloured spots on the integument, so that, as Dr. Grant remarks, a more intimate acquaintance with this character might be useful in tracing relations among the different species. The colour of the ink in Loligo sagittata is a deep brown, approaching to yellowish brown when much diluted, and corresponds remarkably with the coloured spots on the skin of that species; but in Octopus ventricosus the colour of the ink is pure black, and it is blackish grey when diluted on paper. The ink brought in a solid state from China has the same pure black colour as in the Octopus ventricosus, and differs entirely in its shade, when diluted, from that of the Loligo sagittata, as may be seen from specimens of these three colours on drawing paper. Swammerdam suspected the China ink to be made from that of the

poda, except the Sepiæ, can use the ink for concealment and escape, for they possess but a small quantity of the liquid, which they only expel when dying.—Edwards' *Eocene Mollusca*, i. 4. I have, however, been told by our fishermen, that they have seen both the Octopus and Loligo eject the black liquid, with considerable force, and in large abundance, on being just taken from the sea. And so also Owen in Cyclop. Anat. and Phys. i. 536.

* Bancroft on Colours, ii. 430.

† "From this connection of the ink-bag with the liver in the Poulp, Monro was led to suspect it to be the gall-bladder. What its real nature may be still remains doubtful; De Blainville and Jacobson regard it as a rudimental urinary apparatus; Sir Everard Home compares it to the secreting sac which opens into the rectum in rays and sharks, and this we consider to be the true homology of the ink-bag. It is interesting, indeed, to observe that corresponding anal glandular cavities in the mammalia are in many instances modified to serve by the *odour* of their secretion as a means of defence, just as the part in question operates in the Cephalopods by reason of the *colour* of the ejected fluid."—Owen *in Cyclop. Anat. and Phys.* i. 536.

Sepia; Cuvier found it more like that of the Octopus and Loligo; but different kinds of that substance are brought from China, probably made from different genera of these animals, where they abound of gigantic size.* At the present day, according to Cuvier, an ink is prepared from the liquor of these animals in Italy, which differs from the genuine China ink only in being a little less black.† Davy found it to be "a carbonaceous substance mixed with gelatine;" but, on a more careful analysis, Signor Bizio procured from it a substance *sui generis*, which he calls melania. "The melania is a tasteless, black powder, insoluble in alcohol, ether, and water, while cold, but soluble in hot water: the solution is black. Caustic alkalies form with it a solution even in the cold, from which the mineral acids precipitate it unchanged. It contains much azote: it dissolves in, and decomposes, sulphuric acid: it easily kindles at the flame of a candle: it has been found to succeed, as a pigment, in some respects better than China ink."‡

5. Purples.—Several of the Gasteropods secrete a liquor analogous, in some respects, to the ink of the cuttle-fish. The Aplysiæ pour out at will, or when molested, an abundance of a beautiful purple fluid; so that a single individual can colour the water for some yards around it. This fluid is secreted in a gland of a triangular figure, situated under the base of the fleshy coverlid of the branchiæ, and oozes out from all the free surface of this coverlid.§ Cuvier says,

* Edinb. Phil. Journ. xvi. 316. † Mém. i. 4.

‡ Edinb. Phil. Journ. xiv. 376. In 1815, Dr. Prout gave the following analysis of the colouring matter, or ink, ejected by the cuttle-fish: one hundred parts contain:

"Peculiar black colouring matter	78·00
Carbonate of lime	10·40
Carbonate of magnesia	7·00
Muriate of soda? } Sulphate of soda? }	2·16
Animal matter analogous to mucous	·84
Loss	1·60
	100·00"

"This substance, from the length of time which it takes to subside in water, appears admirably contrived for the purpose of concealing the animal from its enemies, &c. A property also which, added to the permanent nature of its colour, must, as Mr. Kemp observes, render it valuable as an ink, or web-colour."—*Ann. Philosophy*, v. 419, 420.

§ Professor Goodsir says, "Aplysia punctata secretes from the edge and internal surface of its mantle, a quantity of purple fluid. The secreting surface of the mantle consists of an arrangement of special nucleated cells. Those cells are distended with a dark purple matter." He says the same of the Ianthina.—*Anat. and Pathol. Obs.* 23, 24.

that, in drying, the secretion assumes the beautiful deep hue of the sweet scabious (Scabiosa atro-purpurea, Linn.), and remains unaltered by long exposure to the air. Nitric acid, in small quantity, heightened the tint, but a larger dose changed it to a dirty aurora; and potash changed it to a dirty vinous grey colour: both the acid and alkali precipitated many white flakes from the fluid. The smell is faint: there is nothing peculiar in the taste; nor has it any irritating quality, for it may be applied a long time to the skin with perfect impunity.* The liquid of our native species is a beautiful purple when exuded. In dyeing it becomes of a brown colour; and if a tincture is made by macerating the Aplysia in whiskey, the purple colour is retained for some time, but ultimately the tincture assumes a tint much like port-wine.

The excretion which approaches apparently nearest to this in its character is that of the Ianthinæ; but I am not aware that any analysis has been made of it. Planorbis corneus (Fig. 42), also, when irritated by any means, or, as Wallis translates a passage from Lister, by "an injection of a grain of salt, pepper, or ginger, into its mouth," pours forth a purple fluid from the sides, between the fork and margin of the cloak; but the colour is of so fugitive a nature, that no acid or astringent has hitherto been found sufficient to preserve the elegancy of its tint, and from turning to an unpleasant rusty hue.† In this respect it agrees with the liquor discharged by Scalaria clathrus, of which Montagu has given us an interesting history. "The purple juice," he tells us, "may be collected either from the recent or dried animal, by opening the part behind the head; and as much can be procured from five individuals as is sufficient, when mixed with a few drops of spring-water, to cover half a sheet of paper." Neither volatile nor fixed alkali materially affects it; mineral acids turn it to a bluish green, or sea-green; sulphuric acid renders it a shade more inclining to blue; vegetable acids probably do not affect it, since cream of tartar did not in the least alter it. These colours, laid on paper, were very bright, and appeared for some months unchanged by the action of the air or the sun; but, being exposed, for a whole summer, to the solar rays, in a south window, they

Fig. 42.

* Mém. ix. 7.

† Wallis, Nat. Hist. North., i. 371. Lister, in his Anim. Ang. 144, gives a full and very good account of this liquor.

almost vanished. The application of alkali to the acidulated colour always restored it to its primitive state, and it was as readily changed again by mineral acid: in this particular it differs materially from the succus of Buccinum lapillus, which, as we have before remarked, is unalterable."*

It is from the difference pointed out, in the latter part of the sentence just quoted, between the fluid of Scalaria (and, I may add, of Ianthina and Aplysia) and the Buccinum or Purpuriferæ, and because it is from the first of a purple colour, that I cannot agree with Plancus,† Colonel Montagu, and many other naturalists of eminence, in their opinion, of its having formed any part of the Tyrian dye; for unchangeableness was one of the characters that enhanced the value of the latter; and Aristotle and Pliny state expressly that the colour of that fluid, on its first discharge from the animal, was white. Such a coloured liquor can be procured, as these authors say it was procured, from several univalves belonging to the genera Murex and Purpura; ‡ and Colonel Montagu furnishes us with a good account of it in the Purpura lapillus:—"The part containing the colouring matter is a slender longitudinal vein, just under the skin on the back, behind the head, appearing whiter than the rest of the animal. The fluid itself is of the colour and consistence of thick cream. As soon as it is exposed to the air, it becomes of a bright yellow, speedily turns to a pale green, and continues to change imperceptibly, until it assumes a bluish cast, and then a purplish red. Without the influence of the solar rays, it will go through all these changes in the course of two or three hours; but the process is much accelerated by exposure to the sun. A portion of the fluid, mixed with diluted vitriolic acid, did not at first appear to have been sensibly affected; but, by more intimately mixing it in the sun, it became of a pale purple, or purplish red, without any of the intermediate changes. Several marks were now made on fine calico, in order to try if it was possible to discharge the colour by such chemical means as were at hand; and it was found that, after the colour was fixed at its last natural change, nitrous no more than vitriolic acid had any other effect than that of rather brightening it: aqua regia, with or without solution of tin, and marine acid, produced no change; nor had fixed or volatile alkali any sensible effect. It does not in the least give out its colour

* Test. Brit. Supp. 122.

† De Conchis minus notis, 28.

‡ Of Tritonium nodiferum Philippi says, "Animal in siccum positum paullo ante mortem saniem pulcherrime cœlestem exspuit."—*Moll. Sicil.* ii. 184.

to alcohol, like cochineal and the succus of the animal of Turbo (Scalaria) clathrus; but it communicates its very disagreeable odour to it most copiously, so that opening the bottle has been more powerful in its effects on the olfactory nerves than the effluvia of assafœtida, to which it may be compared. All the markings which had been alkalised and acidulated, together with those to which nothing had been applied, became, after washing in soap and water, of a uniform colour, rather brighter than before, and were fixed at a fine unchangeable crimson."*

The fluid excreted by some of these mollusks is of a green colour. When the snail of the Purpura patula is retracted within its shell, if you press on the operculum, a very considerable quantity of a greenish liquor is shed, but it becomes a deep purple in drying; and Adanson is a good authority for saying that the greater number of the species discharge a similar tincture.† The colour of it appears, however, to be more permanent in the species of Cerithium,—a genus not much removed in nature from Purpura. Two specimens of Cerithium armatum were brought alive to London from the Mauritius, kept, during their long voyage, not in sea-water, as you might imagine, seeing that the animal is aquatic, but in a dry state, and affording a remarkable illustration of the tenaciousness of its life. The animal was apparently healthy and beautifully coloured: it emitted a considerable quantity of bright green fluid, which stained paper of a grass-green colour; it also coloured two or three ounces of pure water. This green solution, after standing for twelve hours in a stoppered bottle, became purplish at the upper part; but the paper retained its green colour though exposed to the atmosphere.‡ A tincture made by immersing the animal of Cerithium telescopium in spirits, became of a dark verdigris colour, which it retained for some weeks.§

6. Urinary Secretions. — Blainville seems to be of opinion that the coloured secretions now noticed are analogous to the urinary secretion of vertebrated animals; || but although the opinion has been adopted by many authors,¶ yet of its correctness doubts may be reasonably entertained. Besides their purple fluid, the Aplysiæ occasionally discharge, but in small quantities, a whitish acrid one, secreted by a gland composed of little round hyaline grains, and

* Test. Brit. Supp. 106.

† Senegal, Coquil. i. 106.

‡ Proc. Zool. Soc. iii. part ii. 22.

§ Lib. cit. iii. part ii. 22.

|| Manuel, p. 160.

¶ Raspail's Organic Chemistry, p. 529; Tiedemann's Comp. Physiology, p. 220.

emitted by a circular hole that opens externally a little behind the aperture of the oviduct.* The Doris ejects a similar milky fluid, which, however, comes from the liver, or from a gland so intimately associated with it as not to be separated by any dissection.† The position of this secretory organ is singularly modified in the family Eolidæ, where it is found within the apices of their dorsal papillæ, distributed in correspondency with the disintegrated condition of the liver. The organ, first discovered by Messrs. Alder and Hancock, is "a small ovate vesicle, which communicates with the biliary gland by means of a slender canal below, and at the opposite and narrower end opens externally through a minute aperture at the extreme apex of the papilla." It is filled with elliptical bodies and globules of various sizes, imbedded in a mucus-like water; and these contents are, from time to time, expelled as it were by a convulsive contraction of the vesicle. Immediately on expulsion into the circumfluent water, the elliptical bodies burst the little bags in which they are packed in parcels, and shoot out each a long hair-like tail, as they are being scattered abroad. On one occasion our distinguished friends "observed an individual of Eolis picta, when moving freely about, suddenly, and by a convulsive effort, eject from the points of the papillæ a minute stream of milk-white fluid, which curling upwards, mingled with the surrounding liquid, and was soon lost to view. The fluid exactly resembled the contents of the ovate vesicle when forced out by pressure, and examined with a lens of low power." ‡

In some univalved mollusca, a urinary discharge has been more positively ascertained. Swammerdam detected in the snail a little oblong triangular part, placed near the heart, which he calls the "sacculus calcareus." This organ has a pretty large duct, which runs into the intestine; and Swammerdam believes it to be a gland whereby the calcareous matter of the blood is drained from the body, and deposited in the intestine; "and accordingly we find that such a matter is sometimes mixed with the excrements."§ The organ is found, in a modified shape, in many other mollusca; and some naturalists|| have imagined that the shell was

* Cuvier, Mém. ix. 24. † Cuvier, Mém. v. 16.

‡ Monog. Nudib. Moll. part iii. pl. 7 and 8; Ann. and Mag. N. Hist. xv. 82; Nordmann in Ann. des Sc. Nat. (1846), v. 124.

§ Book of Nature, 49.

|| "The formation of the calcareous matter of their shells, which takes place in a peculiar viscus lying near the heart (sacculus calcareus, Swamm. glandula testacea, Poli").—Blumenbach's *Man. Comp. Anat.* 251, transl.

formed by it, misled apparently by the name given by Swammerdam; for no opinion was ever more groundless or hastily offered. Cuvier considers it as the source of the mucus which snails excrete so profusely when forced to withdraw suddenly into their shells, and with which they fix their shells to smooth bodies:* but Mr. Jacobson has proved that it performs the functions of a kidney. "Chemical analysis of the matter secreted by this organ, has led him to discover in it uric acid, ammonia or calcareous salt, and water. His experiments were made on the great snail (Helix pomatia). He was unable to discover any trace of uric acid in any other part of the animal. And as, in the superior animals, the kidneys are the only organs which, in a state of health, secrete uric acid; and as the calcareous sac of the snails has many other anatomical relations with the kidneys, Mr. Jacobson concludes that this sac represents the kidneys, and must be so considered in all the mollusca which are provided with it."†

7. MUCUS.—All molluscous animals excrete a mucous fluid to lubricate the skin, furnished by the skin itself, or by some crypts situated in it. This mucus is, in general, possessed of no remarkable properties: it is usually colourless, but in some species milky or yellow, as you are aware is exampled among our native slugs; and the Clios, a genus of marine pteropods, envelope themselves, when in danger, with a whitish cloudiness that appears to exude from the whole surface of the body. The smell also which certain mollusks exhale, is probably a principle of this mucus. The Octopus moschatus is distinguished for the "amber scent of odorous perfume," which that cuttle exhales so strongly as to fill quickly a whole apartment, whether the animal be dead or alive, and whence it derives its specific designation.‡ I have already told you that the Aplysia of southern Europe stinks disagreeably; but, according to Rapp, the Tethys entices us not more by its singular beauty, than by its odour, which he compares to that of roses. Rondeletius might doubtless be quoted for a very opposite virtue in Tethys,§ but not by an advocate of the tribe. Helix pomatia smells strong of hemlock, in the beginning of June,—a smell which

* Mem. xi. 26.

† Edinb. Journ. Nat. and Geogr. Science, iii. 325.

‡ Bosc maintains that ambergris derives its scent from this cuttle, on which the whale feeds.—*Hist. Nat. des Vers*, i. 48.

§ "Odore est valde ingrato et pisculento, nauseam movet, splendore diutius inspectantibus dolorem oculorum capitisque adfert, id quod in meipso sum expertus."—RONDEL. *de Pisc.* 527.

does not proceed from browsing on the plant, but from an exhalation peculiar to the season of reproduction; and at the same season the Negritæ are as fœtid as the goat.* Another species of Helix (H. alliaria) smells at times strongly of garlic. "When fresh taken," says Dr. Turton, "it diffuses an odour exactly like the smell of garlic, so powerful that two or three of them will scent a room for some hours;"† and, according to Mr. Sheppard, the collector may frequently be guided to its retreat by this exhalation;‡ so that what Nature doubtless intended as a beneficial gift, will often prove its bane in these evil days.

8. Phosphorescence.—A luminous fluid is secreted by several mollusca. Linnæus tells us, on the authority of Bartholinus, that, when the Octopus vulgaris is opened in the dark, a light so strong and splendid is emitted, as perfectly to illuminate the room.§ The light is, however, faint during life, and not general in the class. The Cleodora is the only reputed phosphorescent species among the Pteropods: and as for the Gasteropods, there is also amongst them only one rival of the glow-worm. This is a slug (Phosphorax noctilucus), a native of the higher mountains in the island of Teneriffe, distinguished by a small pore or disk towards the posterior extremity of the shield, which is of a glossy green in daylight, and luminous at night.||

Of luminous bivalves there are also few examples. Bosc instances the Solens, or Razor-fish;¶ and Kirby, without weighing his authority, has hence concluded that these are the Dactyles of Pliny;** but he should have known that

* List. de Coch. Exer. Anat. 146. Of Unio pictorum Lister says, "hi autem musculi, quibus ova nata sunt ad branchias, hircum vehementer olebant." *Exer. Anat. Tert.* 18.

† Land and Freshwater Shells, 56.

‡ Linn. Trans. xiv. 160. The Nanina, also a land-mollusk, secretes a green fluid for defence. "The fluid poured out from the orifice at the base of the caudal horn-like appendage is of a greenish colour; it exudes when the animal is irritated, and at such times the caudal appendage is directed towards the exciting object in such a manner as to give the animal a threatening aspect."—*Proc. Zool. Soc.* 1834, p. 90.

§ Syst. Nat. p. 658; edit. dec. Oligerus Jacobæus, quoted by Owen, asserts that the Cephalopods are phosphorescent.—*Cyclop. Anat. and Phys.* i. 526. Mr. C. Darwin noticed that an Octopus which he kept in his cabin, was slightly phosphorescent in the dark.—*Journal*, iii. 7.

|| "Corpus crassum, latum; ad partem pallii posteriorem discus marginatus ex ipso pallio confectus, die viridi lucidus; nocte phosphorescens."—*Ann. des Sc. Nat.* xxviii. 308; Griffith's *Cuvier*, xxxix. 328.—Bosc (Coq. iv. 71), and De Montfort (Conchyl. Syst. ii. 216,) assert the Ianthina to be phosphorescent, but neither is good authority on this point.

¶ Hist. Nat. de Coq. iii. 9.

** Bridgew. Treat. i. 240.

Reaumur had rendered it much more probable that the Pholas dactylus, Linn., was the shell the Roman naturalist had in view, though we admit that his description will disturb no conjecture. Pliny says, the phosphoric fluid is so abundant in them that it shines about the mouths of those who eat the Dactyli, shines on their hands, and even on their clothes, from drops falling thereon.* Now Reaumur ascertained that the Pholas secretes the fluid in sufficient copiousness to answer this account; and not from any particular gland, for the whole body oozes with it. He removed the animal from the shell, and on placing it in the dark, the light appeared to emanate from every part of the surface; and on tearing it to pieces the internal parts were found to be equally luminous. When dug out from its furrow, the animal contains much water within the shell, and as it drops out, the drops become luminous in their fall. After having handled this Pholas, Reaumur, at first by accident, and then of purpose, washed his fingers in a glass of water, which then appeared in the dark as a vessel of milk would do in the full light of noon. The light does not last long, and ceases whenever the liquor dries; but it can be revived by moistening the body on which it has dried, though in a faint degree. If the Pholas itself is dried, and moistened after a lapse of four or five days, either with fresh or salt water, the luminosity feebly reappears. Immersed in spirits of wine its luminous property is at once destroyed; and when placed in sea-water, although they have remained long illuminated, yet the light grew faint and fainter until it at length was extinguished. Putrefaction also extinguishes the light; and Reaumur suspects that the sensibility of the mollusk to putridity is so great that it will not show its light when in the vicinity of decaying individuals. Its bluish-white light, in short, is the stronger as the animal is lively, fresh, and supplied with its fluids; and more powerful in summer, and at the period of propagation, than at other times.† The Mytilus lithophagus (Lithodomus, Cuv.) would seem to possess the same remarkable properties, for Mr. Charles Ulysses tells us, "that in the Bay of Naples the fishermen place the

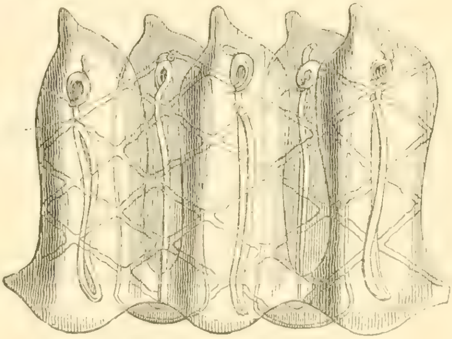
* Hist. Nat. ix. 87.

† Mém. de l'Acad. Roy. des Sc. 1723, p. 292, &c. Tiedemann's Comp. Physiology, p. 260. Macartney in Phil. Trans. 1810, p. 280. The article "Animal Luminousness," by Dr. Coldstream in Cyclop. Anat. and Phys. iii. 197. Forbes and Hanley, Brit. Mollusca, i. 107. Mr. Garner infers that phosphorescence in the mollusca is someway dependent, or at least concomitant, on ciliary motions; but the phenomena seem irreconcilable with this opinion.—CHARLESW. *Mag. N. Hist.* iii. 303.

animal in the sun, and with it besmear their hands and faces at night, so as to illuminate them as with phosphorus."* The two genera have the same habits, lying concealed in deep holes which they have bored in clay and rocks, and for what purpose they light up their gloomy cells, unless it be to allure some minute insect prey, it is hard to guess, for they themselves are "dark in light."

Fig. 43.

A portion of a chain of small Dagysæ of the natural size, and considerably magnified, to show the course of the intestine: *a*, the mouth; *b*, the anus. (From Home's Lect. on Comp. Anat. vol. ii. t. 73).



It is, however, among the Tunicata that the most considerable phosphorescent species are found. The nomad tribes of this order abound in tropical seas; and there are few of them that do not light up their lamps in the dusk. The Salpæ (or Dagysæ of Banks, Fig. 43,) linked together in living chains, and the Pyrosomæ, are the most remarkable examples. Both genera appear to emit the phosphoric flame only when the water is agitated, or when they come in contact with opposing bodies, or when they rise above the surface of the water. In his observations on a species of Salpa, Mr. Beaufort informs us that it gave no light unless the water was violently agitated. "On holding one in my hand," he adds, "and gently pressing it, a faint flame seemed to pervade the whole inside; and on each projecting point there seemed to stand a little globule of very vivid light. On increasing the pressure, its brilliancy likewise increased for a few moments, then gradually declined for some time, as if exhausted by the exertion. It may have been fancy, but, at the time, I was convinced that it gave out a sensible degree of warmth to the hand."† The latter observation is

* Dillwyn's Cat. Rec. Shells, p. 303.

† Home's Lectures, i. 367.—This seems very positive evidence, yet Forbes

probably not fanciful but real; for the great Humboldt has proved that the Salpæ (Biphores of the French), as well as the Pyrosomæ, when preserved in a bottle, make the temperature of the water rise nearly one centigrade degree. The same naturalist, so remarkable for the extent and universality of his knowledge, tells us that the Pyrosoma atlanticum diffuses, "while swimming beneath the surface of the sea, a light of a foot and a half in diameter. Only imagine the superb spectacle which we enjoyed some days ago, when, in the evening, from seven to eleven o'clock, a continuous band of those living globes of fire passed near our vessel. With the light which they diffused, we could distinguish, at a depth of fifteen feet, the individuals of Thynnus, Pelamys, and Sardon, which have followed us these several weeks, notwithstanding the great celerity with which we have sailed."* Mr. Thompson has given an interesting account of the same species. It presents itself to the astonished voyager, in the calm latitudes near to the line, under the appearance of thick bars of metal of about half a foot in length, ignited to whiteness, scattered over the surface of the ocean. Some assume the luminous state, and continue so as long as they remain in view; while, in others, the luminosity declines and disappears.—"The greater number of these apparently incandescent masses pass close to the sides of the vessel, or follow in her wake: their phosphorescence being called into activity by coming in contact with her prow or bottom, as that of such as are more distant appears to be, by the conflict of the waves." The light appears to pervade the whole substance of the animal, and, "when examined near at hand, varies in intensity and in shade, often exhibiting a very beautiful phosphorescence of a bluish or greenish tinge, like a pale sapphire or aquamarine, as it gradually fades away. Agitation or friction renews it, as in other luminous animals, as long as it continues to exhibit signs of life; but it is most vivid when the animal is first drawn up, and at length can scarcely be called forth by the rudest treatment. As we observed this interesting animal, with Milbert's florid description at hand, I can aver that the red, aurora, and orange colours did not present themselves to the eyes of any of our numerous party, who were, nevertheless,

and Hanley say, "Peculiar crustaceans make use of the cavity of the Salpa as a dwelling-place and carriage; and the number of minute phosphorescent animals which lodge themselves within it is often so great as to mislead the observer into the belief that it is the mollusk itself which gives out phosphorescent flashes."—*Brit. Mollusca*, i. 47.

* Edinb. Phil. Journ. xii. 185.

highly gratified at the sight of so brilliant and singular a creature."*

9. Electricity.—In the Edinb. New Philosophical Journal, viii. 204, you will find the following paragraph:—"Mr. Calder mentioned to the Asiatic Society of Calcutta, a molluscous animal which has the property of giving electric shocks, like the torpedo and gymnotus; but neither genus nor species of the animal is noticed." I am not aware that any further notice of it has been published; but I have somewhere read that a species of cuttle-fish had been imagined to possess an electric or galvanic power, and to be thereby assisted in subduing its prey; as the sensations of persons seized upon or touched by the arms of the Cephalopod were stated to be more painful than any which mere mechanical violence of equal force could produce.

10. Heat.—The mollusca have likewise the property of generating heat, though, like other cold-blood creatures, their warmth is much under the control of, and varies with, the atmospheric temperature. Mr. John Hunter found, when the atmosphere was 54°, that four black slugs, put into a small vessel, raised the thermometer to 55° and a quarter.† The experiments of Spallanzani and Gaspard had the same result; while those of Dr. Davy, made on a large snail that abounds in the woods of Ceylon, indicated no change, even after the snail had been confined for eight hours.‡ "According to Berger's experiments, the heat of Helix pomatia varies exceedingly with that of the atmosphere. Its medium warmth was 8·33° during eleven months, the minimum 2·22°, and the maximum 18·33°. In summer it was mostly at 4·44° at sunrise, and at 12·22° towards two o'clock in the afternoon. The heat of bivalve mollusca is, according to Pfeiffer, nearly the same as the temperature of the water in which they live. He found the water in which they were kept to stand at 11·25°, whilst the bulb of the thermometer, placed between the belly and the branchial lamellæ, rose only to 11·56°. J. Davy says he never remarked any difference between the heat of oysters and of the water in which they were." §

* Zool. Illustr. i. 43-4.—Mr. Bennett has described some other remarkable instances of phosphorescence by the Pyrosoma in his "Wanderings in New South Wales;" and in the Proc. of the Zool. Soc. of London.—See in particular, vol. iii. 79, 80.

† Anim. Econ. p. 117, exp. 31.

‡ Edinb. Phil. Journ. xiv. 43.

§ Tiedemann's Comp. Physiology, p. 245.

LETTER XV.

ON THEIR RESPIRATION.

The respiration of the mollusca is so slow, so little obvious, and so easily suspended for a time, that it is possible you may never have observed the process even in those species which daily cross your path. You will, therefore, in your next walk, please to examine the snail or the slug while they are in progression, and you will see them at intervals open wide a circular hole on the side of the neck, and near the margin of the shield or collar, and, after dilating it to the utmost, they will close it again until its place becomes imperceptible; this they do about four times in a minute, expelling at each time the effete air, and inhaling a fresh supply. In like manner, the aquatic tribes, while crawling along the surface, raise from time to time the pulmonary aperture, in order to emit the vitiated air, sometimes even with a crackling noise, and to receive an equal quantity unadulterated before the aperture is shut. This process is not so obvious in the branchial mollusca, and in many of them, from the position of the gills, such a function is not necessary to renew the water around them. Where, however, the gills are strictly internal, it seems probable that the water is regularly changed when the creatures are in their natural habitats and undisturbed: we know that such is the case with the Cephalopoda, in which inspiration and expiration are well marked. "The first (inspiration) is effected by a gradual dilatation of the sac in every direction, but particularly at the sides, accompanied by a subsidence of the lateral valves, collapse of the walls of the funnel, and a rush of water through the lateral openings into the sac. Inspiration being completed, the lateral valves are closed, the sac is gradually contracted, the funnel erected and dilated, and the water expelled through it with great force, and in a continued stream." Dr. Coldstream, from whose letter I quote the preceding sentence, has seen the stream emitted by an individual of the Octopus ventricosus, "whose sac measured about four inches in length, carry light bodies to the distance of eleven inches from the orifice of the funnel. Respiration is performed more frequently in young than in

adult individuals. One, whose sac measured an inch and a half in length, I saw respire eighteen times per minute; and the larger one, mentioned above, respired ten times per minute. The time seemed to be pretty equally divided between inspiration and exspiration." In those bivalves whose cloak forms a shut sac, the water is sucked in through the branchial tube, when the capacity of the sac is increased by its own expansion, or by the opening of the shells; and by its muscular contraction, aided sometimes by the closure of the shells, it is again expelled in a stream from the anal siphon: but there is no regularity in the process in such species as I have observed in confinement. It is the same with the Tunicata. The branchial sac is muscular, and just as its capacity is enlarged, apparently by the contraction of its longitudinal fibres, the water flows in to fill the space in a slow and uniform current, through the branchial aperture only, for none can be detected entering by the anal orifice. It is, after a space, expelled again by a contraction of the annular fibres of the sac, but the voluntary contractions for this purpose, as stated above, take place at irregular intervals of time, and, for the most part, not oftener than once in a minute.*

I have told you that the respiration of the mollusca is at all times slow, and easily suspended for a long period; but, to obviate the inconveniences which might result from this, and to supply the place of that regularly alternate and ceaseless play of the respiratory muscles of the vertebrates, it has been discovered, principally from the researches of Dr. Sharpey, that in the Gasteropod and Acephalous mollusca, the surface of the respiratory organs, and of the cavity in which they are contained, is clothed with minute cilia, which, by their regulated motions, impel the water along the surface in a determinate direction; and by this means a constant current is kept up, and the blood exposed to the influence of successive portions of the surrounding element. Similar cilia clothe many parts of the external surface, and of the inner surface of the alimentary canal; and similar aqueous currents are, by this means, made to flow over them; as if nature meant to avail herself of every exposed part to plant there an auxiliary to the gills, so that under no circumstances should the important function of ventilating the blood and the other fluids be suspended or weakened. You may readily observe these interesting and beautiful phenomena†

* Cuvier, Mem. Mollusc. xx. 17: Coldstream in Edinb. New Phil. Journ. July, 1830, p. 240.

† Leeuwenhoek, who had witnessed them in the common Mussel, with-

by placing a very little naked Gasteropod in a watch-glass of sea-water under the microscope, when, on looking attentively, you will see the water flowing in a rapid even stream over the body and along the tentacula, always in one and the same direction; and a little experience in the use of the glass will soon enable you to discover the minute cilia by which this motion is produced. If you have not by you a living mollusk small enough for the experiment, you may cut off a portion from the branchiæ of any species you can most easily procure—no matter to what class it may belong—and you will find the detached piece exhibiting the same phenomena, and even swimming about in the current it has itself created;*—only this you must remember, that if the animal experimented upon is a marine one, sea-water must be used, for the action of the cilia and impulsion of the fluid are instantly stopped by putting the parts into fresh water.† The important discovery of these ciliary motions enables us to explain satisfactorily some appearances which puzzled the earlier anatomists. Thus Carus observed that the respiratory current of water that flows in upon the bivalves is not intermittent, as in almost all other animals, but uninterrupted, so that these animals, when not too deeply immersed, form an eddy on the surface of the water. Now as such a current cannot be caused by the alternate opening and shutting of the shell, Carus was induced to conjecture that it "must depend on a very peculiar mechanism, which consists chiefly in the muscularity of the cloak, but partly also in the mobility of the gills themselves, and may be compared to the mechanism of certain bellows, which produce an uninterrupted current of air by means of double bags."‡ Blainville, on the contrary, supposed that the triangular labial appen-

out, however, having detected the cilia, says—"Upon examining that part of the Mussel which is called the beard, I not only found it of a wonderful make, but the motion I saw in the small component parts of it was so incredibly great, that I could not be satisfied with the spectacle; and it is not in the mind of man to conceive all the motions which I beheld within the compass of a grain of sand."—*Select Works*, i. 77. I agree with the fine old Dutchman; and the impression of the spectacle, as I saw it in the microscope of my friend Mr. Bowerbank, only deepens with reflection.

* The soft gelatinous substance which supports the cilia on the branchiæ of the mollusca is readily detached in flakes by compression or friction. These little detached flakes move about, agitating their cilia, like living Infusoria; and Müller has described them as species of his genera Trichoda and Leucophra.—Dujardin. *Hist. des Infus.* p. 147 and 677.

† Sharpey in Edinb. Med. and Surg. Journ. xxxiv. 118, &c. Edinb. Journ. Nat. and Geogr. Sc. ii. 334. Cyclop. Anat. and Phys. i. 619, &c. Edinb. New Phil. Journ. ix. 383.

‡ Comp. Anat. trans. ii. 148.

dages placed round the mouth excited the current by their constant motion,—a very inadequate means, even were it true, which it is not, that these organs are in continual motion. They are, however, like the gills, clothed with cilia; and therefore are not undeserving the appellation they have sometimes got of "accessory gills."

The purpose of the respiratory organs and of the currents just described, is, to expose the blood freely to the purificative action of the atmospherical air, that it may be purged of some noxious qualities which it has acquired during its circulation through the venous system, and fitted again for the continuance of the life of the individual. In the vertebrate animals the blood is altered, even in its outward appearance, by this process,—from a dark it becomes a bright red fluid, but no perceptible change is operated on the white serous blood of the mollusca. Yet that it has experienced a similar purification is not to be doubted; for the air breathed by these creatures is similarly deteriorated, as it would have been had it been breathed by the quadruped or bird; the oxygen has disappeared, and its place become occupied by an equal bulk of carbonic acid gas. This had been proved by the well-known experiments of Spallanzani and other physiologists; and though, in general, the proposition holds good, yet it appears, from the recent experiments of Treviranus, that the absorption of oxygen is not always proportional to the excretion of carbonic acid, the proportion of the one to the other depending on the strength of the respiration, the time of its continuance while the respirability of the air is diminishing, and the volume of the air in which the respiration is performed. "The more carbonic acid," says Treviranus, "there is developed while breathing in the open air, and the less the power of continuing in a medium deficient in oxygen, the less is the proportion of the consumption of oxygen to the production of carbonic acid gas, whence a small quantity of atmospheric air is respired for a moderate period. But when the respiration is continued for a longer period in the same air, and the strength of the individual begins to sink, the excretion of the latter diminishes more rapidly than the absorption of the former. We know that the higher classes of animals, when enclosed in a certain quantity of air, die long before all its oxygen has been exhausted. The case is very different with many of the mollusca under the same circumstances; for they not only consume all the oxygen, but actually continue afterwards to exspire carbonic acid gas; consequently, after the respi-

ration has been continued for some time, there has been more of the latter excreted than there has been consumed of the former; nay, sometimes this occurs even before all the oxygen has been consumed."* These observations may serve to explain, in some degree, the apparent apathy of the mollusca generally to a temporary deprivation of their respiratory media, for snails may be immersed in water for many hours without injury; † and the purely aquatic species will survive as long a time exposed to the atmosphere. "The species of Voluta and Buccinum generally (particularly B. oliva and B. harpa,") says Mr. C. Collier, "die in a few hours; those of Strombus and Murex survive thirty-six, forty-eight, and even sixty hours; Trochus niloticus and turritus live yet longer; and Strombus palustris will live several days." ‡ Oysters and mussels, as every one knows, and probably all the Conchifera, will live for three or four days without any more water to breathe in than what may lie in the concavity of their shells; and Mr. Boyle has some experiments which illustrate, in a remarkable manner, their tenacity of life even in vacuum. He found that two oysters put "into a very small receiver," exhausted of air, were alive at the end of twenty-four hours; "but how long afterwards they continued so I did not observe." § Another oyster was put into a vial full of water before being enclosed in the receiver, "that, through the liquor the motion of the (air) bubbles, expected from the fish, might be more pleasantly seen and considered. This oyster proved so strong as to keep itself close shut, and repressed the eruption of the bubbles, that in the other did force open the shells from time to time; and kept in its own air as long as we had occasion to continue the trials." || Shelled snails (Helices) appeared to be not more disordered in vacuity; and even the slugs (Limax) endured the privation for many hours. The same illustrious philosopher included two of the latter "in a

* Edinb. New Phil. Journ. April, 1833, p. 383. The Rev. Mr. Guilding has conjectured that some mollusca may even purify water:—"Neritinæ are destroyed with great difficulty: some, which were even kept close in salt water, seemed to have the power of purifying it, and rendering it fit for respiration; while many large air-bubbles were generated in the glass. Some power of this kind would be very valuable to those species which inhabit maritime ponds, the waters of which, nearly dried up at certain seasons, must be stagnant and unwholesome."—*Zoological Journal*, v. 33.

† Müller mentions that a variety of Helix nemoralis lived a whole summer at the bottom of a rivulet.—*Verm. Fluv. et Ter. Hist.* ii. *pref.* xi.

‡ Edinb. New Phil. Journ. vii. 230.

§ Phil. Trans. 1670, p. 2023.

|| Ibid. p. 2024.

small portable receiver," carefully exhausted; "but, though they did not lose their motion near so soon as other animals were in our vacuum wont to do, yet, coming to look on them after some hours they appeared moveless and very tumid; and, at the end of twelve hours, the inward parts of their bodies seemed to be almost vanished, and they seemed to be but a couple of small full-blown bladders; and on the letting in of the air they immediately so shrunk, as if the bladders had been pricked: the receding air had left behind it nothing but skins; nor did either of the snails afterwards, though kept many hours, give any signs of life."* In this experiment, it is obvious that the snails were killed from the mechanical effects of the expansion of the air within them, and not from its ingress to the pulmonary cavity being prevented.

But there are on record some extraordinary facts, which seem to prove that, under certain conditions, all of which are not yet known, the respiration of many mollusca, more especially the terrestrial, may be suspended for an indefinite period, and again renewed by the application of heat and moisture; life, as it were, keeping watch, and holding at bay every destructive agent, but without giving any outward sign of her presence and constant wakefulness, until the return of those influences in which she joys. "All the land testacea," to use the words of Dr. Fleming, "appear to have the power of becoming torpid at pleasure, and independent of any alterations of temperature. Thus, even in midsummer, if we place in a box specimens of the Helix hortensis, nemoralis, or arbustorum, without food, in a day or two they form for themselves a thin operculum, attach themselves to the side of the box, and remain in this dormant state. They may be kept in this condition for several years. No ordinary change of temperature produces any effect upon them, but they speedily revive if plunged in water. Even in their natural haunts, they are often found in this state during the summer season, when there is a continued drought. With the first shower, however, they recover, and move about; and at this time the conchologist ought to be on the alert."† I may illustrate these remarks, which are perfectly correct, by some additional examples; one or two of which you may find to require an exercise of faith for which you may not be altogether prepared. Some Ampullariæ from the Nile, being packed in saw-dust, revived after their arrival in Paris on being

* Phil. Trans. 1670, p. 2050.

† Phil. Zool. ii. 77.

put into water, though an interval of more than four months had elapsed. Deshayes explains this long endurance in this genus from a peculiarity in the structure of the respiratory organs, for not only is the branchial cavity more than ordinarily capacious, but there is a supplementary sac which is not found in other genera of its order. After the snail has withdrawn itself, and closed the aperture of its shell with the operculum, the water is retained in this sac, and the branchiæ thereby kept in a moist and unshrivelled condition; * while, perhaps, its contact with a living surface prevents the retained fluid running into putrefaction. Mr. Lyell tells us that "four individuals of a large species of Bulimus, from Valparaiso, were brought to England by Lieutenant Graves, who accompanied Captain King in his late expedition to the Straits of Magellan. They had been packed up in a box and enveloped in cotton, two for a space of thirteen, one for seventeen, and a fourth for upwards of twenty months; but on being exposed by Mr. Broderip to the warmth of a fire in London, and provided with tepid water and leaves they revived, and are now living in Mr. Loddiges's palm-house." † Dr. Elliotson put a garden-snail "into a dry closet, without food, a year and a half ago; it became torpid, and has remained so ever since, except whenever I have chosen to moisten it. A few drops of water revive it at any time." ‡ Similar instances may be found in some of the periodical journals; but they are as nothing when compared with the snails of Mr. Stuckey Simon, a merchant of Dublin, which, on being immersed in water, recovered and crept about after an uninterrupted torpidity of at *least fifteen years;* § and I agree with Mr.

* Ann. des Sc. Nat. xxix. 270.

† Princip. Geol. ii. 109. 8vo. edit. See also Edinb. New Phil. Journ. xvi. 392, for some similar facts.

‡ Blumenbach's Physiology, p. 182.—In the Ephemerid. Acad. Leopold. cent. 7. p. 184, a case of a boy is related who voided four shelled snails that he had swallowed; and the snails, on their expulsion, crept about with sufficient vivacity.

§ "Mr. Stuckey Simon, a merchant of Dublin, whose father, a fellow of the Royal Society, and a lover of natural history, left to him a small collection of fossils and other curiosities, had among them the shells of some snails. About fifteen years after his father's death (in whose possession they continued many years), he by chance gave to his son, a child about ten years old, some of these snail-shells to play with. The boy put them into a flower-pot, which he filled with water, and the next day into a basin. Having occasion to use this, Mr. Simon observed that the animals had come out of their shells. He examined the child, who assured him that they were the same he had given him, and said he had also a few more, which he brought. Mr. Simon put one of these into water, and in an hour and a half after observed, that it had put out its horns and body, which it

Bingley in thinking that this is a well-authenticated fact. Whether what follows is so, I leave to your own decision; but I will not say you are unreasonably sceptical if you deem it too tramontane. "Professor Eaton, of New York, stated," says my authority, "that the diluvial deposits through which the Erie Canal was made contained ridges of hard compact gravel. On cutting through one of these, near Rome village, sixteen miles west of Utica, the workmen found several hundred of live molluscous animals. They were chiefly of the Mya cariosa and Mya purpurea. The workmen took the animals, fried, and ate them. He adds, I was assured that they were taken alive forty-two feet deep in the deposit. Several of the shells are now before me. The deposit is diluvial. These animals must have been there from the time of the deluge, for the earth in which they were is too compact for them to have been produced by a succession of generations. These freshwater

moved but slowly, probably from weakness. Major Vallancy and Dr. Span were afterwards present, and saw one of the snails crawl out, the others being dead, most probably from their having remained some days in the water. Dr. Quin and Dr. Rutty also examined the living snail several different times, and were greatly pleased to see him come out of his solitary habitation after so many years' confinement. Dr. Macbride, and a party of gentlemen at his house, were also witnesses of this surprising phenomenon. Dr. Macbride has thus mentioned the circumstance:—'After the shell had lain ten minutes in a glass of water that had the cold barely taken off, the snail began to appear, and in five minutes more we perceived half the body pushed out from the cavity of the shell. We then removed it into a basin, that the snail might have more scope than it had in the glass; and here in a very short time, we saw it get above the surface of the water, and crawl up towards the edge of the basin. While it was thus moving about, with its horns erect, a fly chanced to be hovering near, and, perceiving the snail, darted down upon it. The little animal instantly withdrew itself into the shell, but as quickly came forth again when it found the enemy had gone off. We allowed it to wander about the basin for upwards of an hour, when we returned it into a wide-mouthed phial, where Mr. Simon had lately been used to keep it. He presented me with this remarkable shell; and I observed, at twelve o'clock, as I was going to bed, that the snail was still in motion; but next morning I found it in a torpid state, sticking to the side of the glass.'"—*Phil. Trans. abridg.* xiii. p. 566.

"A few weeks afterwards the shell was sent to Sir John Pringle, who showed it at a meeting of the Royal Society; but some of the members imagining that Mr. Simon must have been imposed upon by his son having substituted fresh shells for those that had been given to him, the boy was re-examined by Dr. Macbride on the subject, who declared that he could find no reason to believe that the child either did or could impose upon his father. Mr. Simon's living in the heart of the city, rendered it almost impossible for the boy (if he had been so disposed) to collect fresh shells, being at that time confined to the house with a cold. Mr. Simon has also declared that he is positive those were the shells he gave to him, having in his cabinet many more of the same sort, and nearly of the same size."—Bingley's *Animal Biography*, vol. iii. p. 574.

clams of three thousand years old precisely resemble the same species which now inhabit the fresh waters of that district; therefore, the lives of these animals have been greatly prolonged by their exclusion from air and light for more than three thousand years." *

With the exception of the last example, the others refer to land testacea; but some pulmoniferous aquatic species are equally capable of assuming this state of torpidity, when under circumstances which deprive them of their respiratory medium. In early spring, I have more than once observed the Limnæus fossarius to abound in small pools of water, which were dried up as the season advanced; and when, after a careful search, the little snails were found, in a torpid condition, concealed in the cracks made by the drought, or under small clods of earth, where they awaited a happier season to refill their pools, and permit them to resume the functions of active life. Perhaps, in this country, their torpidity can rarely be continued beyond a few weeks; but in tropical climes similar species can pass the dry season of five long months in this state. Thus, Adanson informs us that the minute freshwater shell, which he calls Bulimus, is to be seen only from the month of September to January, in the marshes of Senegal, formed by the rains which fall in June, July, August, and September. When these marshes are dried up, and, as it were, roasted by the sun, the shell-fish disappear; a few empty shells alone being left to show where they had been; but they never fail to return with the rainy season; and Adanson remarked that, the hotter the preceding summer, the more abundant was the issue of the succeeding hordes. How, asks the author, shall we explain this marvellous reproduction? Can the eggs of the animal, necessarily very delicate and minute—can they remain in a soil so burned up without being entirely dried; or can the animals themselves, if it is true that they conceal themselves in the bosom of the earth, can they resist during five or six months the heat of a burning sun? † The latter supposition is the only one which can, I think, solve the question.

When in this torpid state the condition of the snail itself has not been ascertained. Some authors speak of it as being dormant; and the language would seem to imply that they consider it in a state of sleep, in which the circulation and respiration go on uninterruptedly and as strongly as when awake; but I suspect that the authors alluded to

* Silliman's Amer. Journal, No. xv p. 249, as quoted in Turner's Sacred History, p. 473.

† Hist. Nat. du Senégal, p. 7.

never intended that such an inference should be drawn from their analogical language. The fact is, it is not known precisely whether the circulation goes on or is stopped, or whether the contact of air is essential or otherwise. It is difficult to believe that all the functions as well as the signs of life cease entirely; and yet it is scarcely less so to suppose that, for the space of fifteen years or more, those functions could exist without some supply of food to keep up the waste and secretions, however trivial, which necessarily flow from a circulation, or without some air to purify the circulating fluid. *

If I deem it necessary to distinguish torpidity from sleep, it is, perhaps, not less so to distinguish it from the state of hybernation, although the phenomena of both are more strictly analogous. † Snails become torpid when the atmosphere is hot and dry;

> "When with their domes the slow-paced snails retreat,
> Beneath some foliage, from the burning heat;"

and, as often as they are unbound by the application of a warm moisture, they come forth from the shell strong and vigorous; but, "intelligent of seasons," they begin instinctively to seek hybernating quarters at a moist season of the year, and before the cold has benumbed their powers; and, if roused untimely, their languid movements evidence

* "This living principle has the singular property of remaining dormant and inert for years or ages; without, therefore, ceasing to exist. We all know that seeds may be kept a long while unsown, and yet grow whenever planted in a suitable soil. This, again, is like animals which have been found enclosed in trees, and yet have revived. When plants are buried in the ground to a greater depth than is natural to them for their proper growth, they do not vegetate; but they do not therefore die: they retain their power of vegetation to an unlimited period; and when, by any accident, brought so near the surface as to suit their evolution, they begin immediately to grow."—TURNER's *Sacred History*, p. 195.

† "A very important distinction is drawn by Dr. Hall, between true hybernation and torpor. Torpor may be produced by cold in any animal, and is attended by a benumbed state of the sentient nerves, and a stiffened condition of the muscles; it is the direct product of cold. But hybernation is limited to a certain number of animals; in it sensibility and power of motion remain unimpaired; its phenomena are produced through the medium of sleep. The nature of hybernation is determined in a great measure by the fact, that all hybernating animals avoid exposure to intense cold, but choose a retreat, make nests or burrows, and congregate at times in clusters. The instinct by which the animals are led to make use of these precautions, is in connection with the law, which requires that the change from the condition of hybernation to that of activity, shall be slow and gradual, inasmuch as the state of the blood in the one condition is incompatible with the peculiar power of the heart in the other."—*Monthly Review for March*, 1833, p. 351.

their weakness, and bespeak our sympathy to leave them to repose. Whether the vital functions in these creatures are similarly affected during torpor and hybernation remains to be determined. It is probable that they are.

In this country, and in others with similar climates, probably all the terrestrial shelled snails, and all the pulmoniferous freshwater mollusca, pass the winter in a state of hybernation. I believe that the naked slugs do not hybernate; for, although they retire under stones, clods of earth, or moss, to protect themselves from the cold and storms of the season, yet I have always found them immediately to resume their activity when taken from their concealments, and they are in motion all the winter in mild weather. It is not certainly known, although the contrary has been asserted,* that any marine molluscum hybernates. Some of the littoral species appear to do so. "Mr. Gray found that many individuals of Littorina petræa, and some of Litt. rudis, were in this condition during his stay at Dawlish. They were attached to the rocks several feet above the reach of the highest autumnal tides; their foot was entirely retracted; and a membranous film was spread between the rock and the edges of the outer lip of the shell: the gills were only moist, the branchial sac being destitute of that considerable quantity of water which exists in it in those of the same species, which are adherent to the rock by their expanded foot. In this torpid condition, the individuals observed by Mr. Gray continued during the whole of his stay, which lasted for more than a week. On removing several of them and placing them in sea-water, they recovered in a few minutes their full activity."†—There would seem to be no necessity that the snails of tropical countries should be endowed with this remarkable property; but the observations of Adanson prove the contrary. He tells us that the Bulimus Kambeul apparently passes the winter, or dry season, in a deep slumber, like the snails of Europe; for he found several of them which were half-buried, in the month of September, at the roots of trees and in the thickest brushwoods; and of these some had already closed the aperture of their shell very exactly with a lid of a whitish and plaster-like matter, to protect themselves against the long droughts which continue for eight or nine months uninterruptedly.‡

* "The marine mollusca probably migrate in part from the shallower to the deeper waters in cold winters; many, however, hybernate."—Duncan *on the Analogies of Organised Beings*, p. 97.

† Proc. Zool. Soc. iii. 116.

‡ Hist. Nat. du Senégal, 18. The reader will find some interesting obser-

None of the hybernating mollusca exhibit any remarkable cunning in the selection of their hybernacula, or winter quarters. On the approach of the cold weather the terrestrial tribes dig into the ground or seek out a convenient station in crevices of old walls, at the roots of coarse grass, or in tufts of moss, and, retiring within the shell, they close up its aperture by a membranous or calcareous epiphragm, which serves, at the same time, to fix or cement the shell to the wall or body against which it rests.* At the same period the aquatic tribes descend to the bottom of their ponds and ditches, sink a little in the soft mud, and cover over the mouth of the shell with a transparent gelatine. In general when the temperature of the air sinks below the fiftieth degree of Fahrenheit, cold-blooded animals begin their winter slumber, and, previously prepared by that instinct which operates as wisely as if right reason had foreseen the coming evil, they gradually, with the increasing cold, sink into a state which resembles more the stillness of death than the quietness of sleep; a state without motion, or feeling, or sense, or heat, and in which the heart and lungs, the vital organs, perform their functions more and more feebly, until they also rest still in the general quiescence; and in this death-like condition these animals continue "for five, six, seven, or even eight or nine months, according to the climate and season," until the genial warmth and dews of spring recall them anew to life and action.†

M. Gaspard has given a minute and a very interesting account of the hybernation of Helix pomatia in the first volume of the "Zoological Journal," to which I must refer you for the particulars. This species forms, by aid of its foot and a very glutinous secretion, an excavation, or nest, in which it buries the shell, and it then closes the aperture with a thick calcareous epiphragm, and with several interior membranous partitions, which are more numerous at the end than at the beginning of winter, and in the snails inhabiting the mountains than in those found on low ground. Thus buried and enclosed it passes six months in a state

vations on the torpidity of the Bulimi, by Mr. Reeve, in Ann. and Mag. N. Hist. ser. 2, i. 272.

* "It is composed of a viscous slabber, from the body of the animal which condenses into a kind of toughish coriaceous, or leather-like, substance, and is pretty thick. This lid, or crust, is never attached to the body of the animal, as in the sea-univalves, but merely covers the mouth; nor is it ever wrought with a spiral or with concentric circles, or indeed any other regular work."—Da Costa, *Elem. Conchology*, p. 121.

† Helix naticoides passes ten months of the year in this state, buried to the depth of twenty centimetres in the earth."—Drap. *Mollusq.* p. 93.

of total torpidity; for the only indication of irritability perceptible during this period is a slight contraction of the collar of the mantle when touched on removing the epiphragm. He found that there was no digestion; the heart at first beat feebly, and with a very slow pulsation; but at a later period it was found to have stopped, and the circulation was entirely suspended; respiration ceased; no animal heat, which even in the summer, when respiration and circulation are most lively, does not exceed one degree above the surrounding atmosphere, was evolved; no secretions nor wasting function went on, neither any growth or reproduction of new parts. "In our climate it is about the beginning of April, soon after the song of the cuckoo begins and the swallows appear, that the snails leave their torpid state; varying a little, however, according to the season. The mode by which their escape from confinement is effected is simple and easily comprehended. The air which is contained in the different cells, and which had been expired on the animal withdrawing itself farther and farther into the shell after the formation of the operculum, is again inspired, and each separate membranous partition broken by the pressure of the hinder part of the foot projected through the mantle. When it arrives at the calcareous operculum, the animal, making a last effort, bursts and detaches its most obtuse angle. Then insinuating by little and little the edge of the foot between the shell and the operculum it forces the latter off, or breaks it away. The animal then comes forth, walks, and immediately begins feeding, with an appetite excited, doubtless, by an abstinence of six or seven months." *

Such is M. Gaspard's account of the reviviscency of Helix pomatia, and the process must be still simpler in the other species; for they have merely to rupture a single horny or semigelatinous membrane. But there has been a difference of opinion relative to the source of the air which is first respired. Gaspard, you will observe, says that that portion which is confined between the layers of the epiphragm is the first inhaled; and, in coincidence with this opinion, we must infer that the species with a single membrane respire in the first instance the air behind it, and then, by their own efforts, burst their prison wall. A very different explanation of the process has been advanced by Sir Everard Home. He says: "When warmth and moisture are applied, the membranous film (of the garden snail) falls off; a globule of

* Zool. Journ. i. 99.

air that remained in the cavity of the lungs becomes rarefied, and forces its way out, and admits of fresh air being applied to these organs."* I suspect that more of fancy than of observation enters into the baronet's theory; for were the rarefaction of the contained air, and its egress through the pulmonary aperture, all that was necessary to shake off the winter slumber, this would be done on several days in winter and in early spring, when the sun shines brightly and the atmospherical temperature is high enough to produce the effect, often higher, indeed, than it is when they begin, in the appointed time, to leave their hybernating retreats. If, says M. Gaspard, individuals of Helix pomatia "were exposed during the winter to a dry heat of from 60° to 100° for several days, or even weeks, not one made its appearance; whilst, on the contrary, those which were placed in a deep recess, the regular temperature of which was 50°, came forth in April, or at the beginning of May, without any increase of temperature."

Dr. Turton, on the other hand, maintains that the doctrine of Gaspard is equally untenable; for that the direct communication between the external air and the animal within its shell is never interrupted, but on the contrary preserved, by means of a small aperture in the epiphragm. His words are: "But, upon examination, it will appear, that in the centre of this epiphragm (of Helix pomatia) is an exceedingly minute orifice, communicating with an umbilical cord, which is connected with a fine placenta-like tissue of vessels, penetrating into the pulmonary cavity itself; and this minute orifice, although not large enough to admit a drop of water, is of sufficient capacity for the passage of that

* Comp. Anat. iii. 156. — In the following extract, Sir E. Home repeats his hypothesis in a more detailed manner:—" It is curious that, although respiration is necessary for carrying on the functions of life, it is by no means so for the continuance of its existence. The garden-snail illustrates this fact in the most satisfactory manner. When the temperature of the atmosphere sinks below a certain degree, this animal places itself upon a solid body, that it may not be liable to fall off: it then forms an operculum of mucus, by which respiration is stopped, and the animal remains hermetically sealed up, till warmth and moisture dissolve the mucus by which the animal was fixed to its place; and a globule of air retained in the lungs, which consist only of one cell or bag, being rarefied, escapes externally, restoring the communication with the air of the atmosphere which rushes in, and the action of the heart is renewed. If it is admitted that the application of oxygen to the muscles of the heart is capable of stimulating that organ, nothing can be more simple, than the mode in which this is effected: the oxygen of the atmosphere is absorbed by the blood in the lungs, and the closeness of the ventricle of the heart to the lungs, permits the oxygen to penetrate to the heart."—*Comp. Anat.* v. 129.

quantity of oxygenated air necessary for the purposes of extremely slow, but not totally extinct, respiration. If this orifice be covered over with a coat of wax or varnish, so that all possible connection with external air be excluded, animal life becomes altogether extinguished, never to be again restored. We have observed this minute puncture in the winter covering of the H. ericetorum and some others; and it is probable that all whose aperture is closed during the cold season only, are furnished with this beautiful apparatus for the preservation of life." * I recommend you to examine into these statements; and, if your own observations confirm them, they will materially alter some inferences which have been drawn from Gaspard's experiments, and adopted by us, in reference to the *total cessation* of the action of the lungs and heart. Helix pomatia does not reach this northern latitude; but I have examined, too carelessly, however, the epiphragm of Helix aspersa during its hybernation, and always find a small aperture in it; and also, in the aquatic tribes, I find a larger hole in their thin winter operculum, intended, assuredly, to keep up the communication between the pulmonary cavity and the circumambient medium in their season of repose.

There is something admirable in this curious adaptation of the economy of the hybernating creatures to their situations; for otherwise they could not live beyond a single summer in the countries which they now inhabit with impunity to themselves. If, during their active state of existence, you were to keep a Limneus, or any other aquatic pulmoniferous species, immersed in water for only one short day, or even for little more than an hour, it would die irrecoverably; but it remains under water, perhaps with the surface frozen over, for three or four months uninjured, when the system has been prepared, in autumn, for the change.† And so of the land kinds: they perish if deprived of air for a few hours only in summer, or if exposed to an artificial cold not lower than the cold of winter; but in a state of hybernation they respire, if any, such a small quantity of air as is not to be appreciated, and brave our longest and severest frosts without peril and without pain. "O Lord, how glorious are thy works! thy thoughts are very deep!"

Have patience with me while I bestow on you a little more of my tediousness in the notice of one or two points

* Manual of Land and Fresh-water Shells, p. 46.
† Encyclop. Method. i. 296.

that had nearly slipt from my remembrance. It has, I think, been very generally received as an axiom in physiology that the power of locomotion bears a ratio to the perfection of the respiratory organs: the more perfect the latter, and the greater their capability of submitting the blood to the action of the oxygenating medium, the more vivacious and agile the animal in its movements. Thus, the cuttle-fish, with their laminated and highly-developed gills, move in the bosom of the ocean with quickness and vigour; and the pulmoniferous and pectinibranchial mollusks have been advantageously contrasted with the sedentary bivalves and the ascidians. But the latter comparison is surely an unfortunate one, for I know no mollusks in which the gills are so large in proportion to the body as in the fixed oyster and anchored mussel. Indeed, in regard to the mollusca the axiom will not hold good. Some of the bivalves, such as the Cyclas, move with little less rapidity than the Limneus and pulmoniferous Gasteropods; and the water-breathing Rissoæ are more quick of foot by far than the slugs and snails which breathe uncombined air. Even in the same tribe and family there are such differences in respect of speed that it seems impossible to ascribe much influence on it to any formation of the gills. Thus, the Buccinum undatum is preeminently tardigrade, but its near ally the Nassa maculata is quick and active; and similar examples may be easily pointed out.

Nor do I believe that there is any connection between any structural peculiarities of the respiratory organs and the varying depths in which the mollusca do live. In his masterly anatomy of the Brachiopoda, Professor Owen would seem, perhaps, to intimate the contrary. He says, that to the Ligula a respiratory apparatus more complex and obvious than that of the Terebratula, was indispensable, because the former lives more commonly near the surface, and where it must meet with a greater variety and abundance of animal nutriment than can be found in those abysses in which Terebratula is destined to reside. He continues: "The respiration, indeed, as well as the nutrition of animals living beneath a pressure of from sixty to ninety fathoms of sea-water, are subjects of peculiar interest, and prepare the mind to contemplate with less surprise the wonderful complexity exhibited in the minutest parts of the frame of these diminutive creatures. In the stillness pervading these abysses they can only maintain existence by exciting a perpetual current around them, in order to dissipate the water already loaded with their effete particles, and bring within

the reach of their prehensile organs the animalcula adapted for their support. The actions of Terebratula and Orbicula, from the firm attachment of their shells to foreign substances, are thus confined to the movements of their brachial and branchial filaments, and to a slight divarication or sliding motion of their protecting valves; and the simplicity of their digestive apparatus, the corresponding simplicity of their branchiæ, and the diminished proportion of their soft to their hard parts, are in harmony with such limited powers. The soft parts in both genera are, however, remarkable for the strong and unyielding manner in which they are connected together: the muscular parts are in great proportion, and of singular complexity as compared with ordinary bivalves; and the tendinous and aponeurotic parts are remarkable for the similarity of their texture and appearance to those of the highest classes. By means of all this strength they are enabled to perform the requisite motions of the valves at the depths in which they are met with. Terebratula, which is more remarkable for its habitat, has an internal skeleton superadded to its outward defence, by means of which additional support is afforded to the shell, a stronger defence to the viscera, and a more fixed point of attachment to the brachial cirri." * This interesting passage cannot fail to please you, and its scope is, generally speaking, correct and just; but if thence you infer that the Terebratulæ reside *only* in the unfathomed depths of the ocean, you will be misled, for specimens of the recent species have been taken from under rocks that were left uncovered by a spring-tide. Many bivalves too, which differ in nothing material from littoral species, have their abode in very deep water; and Mr. Broderip furnishes me with a striking instance of the various depths which species even of the same genus affect. In describing some species of Clavagella, he says: "Clav. australis was so near the surface at low water, that it was detected by its ejection of the fluid; Clav. elongata, from the nature of the coral in which it is chambered, could not have been living far beneath the surface; whereas Clav. lata was dredged up from a depth of sixty-six feet. Any inferences, therefore, as to the state of submersion of a rock during the life of the fossil species of Clavagellas which there occur, should be made with caution by the geologist." †

* Zool. Trans. i. 158. † Ib. i. 267.

LETTER XVI.

ON THEIR ORGANS OF RESPIRATION.

The respiratory organs of the mollusca have peculiar claims to the attention of the conchologist, not solely because of their function, which, indeed, is one of chief importance, but because they have furnished the principal characters on which modern systematists have proceeded to subdivide the class into orders and families. Cuvier, of whom, among recent naturalists, it may most truly be said that he was

> "Ordain'd to light with intellectual day
> The mazy wheels of Nature as they play,"

was the first to perceive their utility in this respect; and when it is considered that their position mainly determines the arrangement of the other viscera, and must consequently exert a powerful influence over the habits of the animals, you will feel disposed to admit that a happier choice could not have been made, the more particularly as the organs in question are in general easy to detect, and exhibit sufficient variety in location and form for every systematic purpose.

Molluscous animals are either *Pulmoniferous*,* and breathe atmospheric air only, or they are *Branchiferous*, and respire it through the medium of water. In the former the respiratory organ is a simple cavity, commonly situated on the anterior part of the back; but sometimes, as in Testacella, near the tail. The air is admitted by a small circular aperture that opens outwards on the neck under the margin of the cloak, and which the animal opens and shuts at pleasure. Externally the cavity is protected either by a thick fold of the cloak, often strengthened with a horny or calcareous

* Lamarck objects to the use of this term, as applied to the mollusca, Anim. s. Vert. vi. ii. 44; and hence some have called the order *Pneumonobranchous*. But there is no good reason in the objection. The distinction between a lung and a gill, rests on anatomical structure. When the air is operated on through the medium simply of an internal cavity or cavities, the respiration is pulmonary; when, on the contrary, processes or gills project from the cavity or from the surface, and expose the blood to the air by the vessels which are distributed on these processes and folds, the respiration is branchial.—Milne-Edwards, *Hist. Nat. des Crustacés*, i. 91.

plate, or by the body-whorl of the shell; while its interior walls, and more especially its roof, are covered with a fine vascular network, formed by the minute ramifications of the pulmonary vessels, which thus expose the blood freely to the influence of the air, alternately introduced and expelled by the alternate dilatation and contraction of the cavity itself. All the terrestrial mollusca, such as slugs and snails, and the great bulk of the Gasteropoda that inhabit fresh water, possess a respiratory apparatus of this kind; and, since these aquatic Pulmonifera (Limneus, Planorbis, and Ancyllus may be quoted as examples) are necessitated, from time to time, to inhale the fresh and uncombined air, so they will be found uniformly to be the denizens of shallow waters, and to spend a large portion of their lives at the surface.

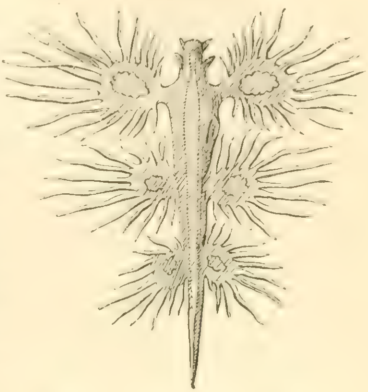
The *Branchiferous* Mollusca have the aerating organs greatly more diversified in every respect; and to countervail the disadvantages of breathing a medium little impregnated with air, the organs are likewise of greater extent and complexity. When placed within the body, the branchiæ, if distinct, are divided into multiplied lobes and leaflets; or, if a mere cavity, the surfaces are folded into innumerable plaits, all calculated to afford ampler space for the display and meanderings of their blood-vessels, and to expose a wider surface to the contact of the water: but, if the branchiæ are external and exposed, they are, it may be, less complicated, only because complexity seems unnecessary where fresh doses of unbreathed fluid are continually brought into momentary contact with them, and without any effort on the creature's part.

The mollusca which have their branchiæ entirely exposed belong to two orders, the Pteropoda and Gasteropoda. A very few, as the Actæon (Aplysia viridis, Mont.) and the nearly allied genus Limapontia, appear to have no other respiratory organ than the common integuments, which have suffered no modification; but in the genus Cribella of Audouin and Milne-Edwards the skin of the mantle is, for this purpose, wrinkled on each side, and perforated with an infinite number of pores.* In a greater number the branchiæ are actually blended with the locomotive organs, as in Clio, a member of the former order, whose fin-like expansions are supposed to perform the office, not of progression only, but also of ventilating the blood as it circulates through the fine regular network with which their surfaces are covered. The Glaucus (Fig. 44) affords another example of the same union

* Edinb. Journ. Nat. and Geogr. Sc. iii. 244.

of functions. This is one of the most remarkable and most beautiful of the Gasteropods. The body glows with a fine cerulean blue colour, which deepens in hue towards the ends of the fringes of its ptero-branchiæ; the centre of the back is of pearly whiteness, bordered with a line of deep blue; and the sides are adorned with an interrupted series of fan-like laciniated gills, by aid of which, as I have said, it swims reversed at the surface of the Mediterranean Sea, in numerous swarms.*

Fig. 44.



Glaucus hexapterygius, copied from Cuvier.

But, generally, the external branchiæ are distinct and independent organs. Of the Pteropoda, almost each genus presents them under some new modification in form, or structure, or position, "as Nature in them strove to show variety." Thus, in the Pneumodermon (Fig. 45), they are placed nearly on the posterior extremity of the body, which is naked, and resemble two Cs placed back to back in this manner, ɔc, united by a little transverse bar across the middle, or at each end, the lines being garnished with a number of regular prominent leaflets of minute size. In the Hyales again, the branchiæ are pectinated, and lie concealed in a space between the lobes of the cloak, to which the water gains admission by certain fissures on the sides of the shell; while, to make, as it were, the dissimilarity perfect, they appear, in the genus Cuvieria of Rang (Fig. 46), in the form

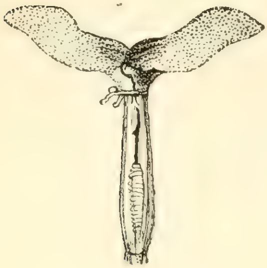
Fig. 45.

Pneumodermon, copied from Cuvier.

*An early, but anonymous, notice of this mollusk is worth quoting: "The mid-line of the back part appeared through a common magnifier like a single leaf, and was in continual undulating motion, either from the muscles or circulation of juices. Two side lines, extending the whole creature's length, and ending in one in the tail, of a deep blue. The fingers, or tentacles, end in a deep blue; a silvery cast intermingled with the blue over the whole back, or upper parts, where the blue is lighter."—*Phil. Trans.* liii. 58.—Mr. George Bennett has given a very interesting account of the habits of the Glaucus in the Proc. of the Zool. Society, pt. iv. 1836, p. 113, 119.

of two small equal and symmetrical processes, exsertile beyond the shell when the animal is in motion, but at other times retracted, and fixed upon a common stalk by a point a little removed from one of the ends.*

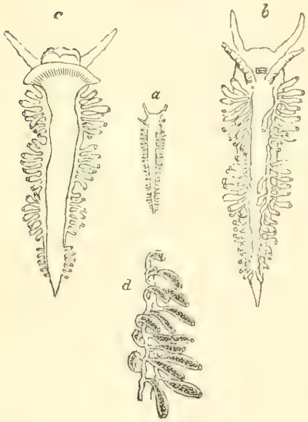
Fig. 46.



Cuviera, copied from Rang.

The Gasteropoda which arrange themselves under this division form a very natural and interesting order, appropriately named by Cuvier the Nudibranches. These are naked snail-like mollusca which live only in the sea; and they would scarcely attract our notice amid the myriads of curious creatures that are around them, were it not for the ornament and singularity of their branchial appendages. Their position is always on some part of the back, either ranged in one or more series along its margins, as in Glaucus, Eolis, and the Tritoniadæ; or clustered on a point of the medial line near the hinder extremity, as in the Doris and its allies, which have the power of concealing them within the body when danger threatens from without. In shape they vary more than in position: they are simple filaments in Eolis (Fig. 47); in Glaucus they are fan-shaped fins; in Melibœa clubbed processes, covered with little hispid tubercles, or, as in Scyllea, with little tufted bouquets of very delicate filaments; and in the Tritoniadæ and Doris they assume a more or less perfectly plumose or arborescent appearance.†

Fig. 47.



* Rang's Manuel de l'Histoire Naturelle des Mollusques, p. 38.

† In reference to the papillary appendages of Eolis, and of the genera which it represents, Mr. Couthouy conjectures that they "are not the real respiratory organs, because he has seen that the animal will voluntarily throw them off, from slight causes, or that it may be forcibly deprived of them without material injury; which, he justly remarks, would not be likely to be the case, were they organs of so much importance as the branchiæ. He is disposed to regard them as merely subsidiary to the function of respiration."—GOULD's *Invertebrata of Massachussetts,* p. 6. Quatrefages has endeavoured to prove the organs in question to be connected with

There are other Gasteropods in which, although not so fully exposed as in the preceding order, the gills are still only slightly concealed by some lap or fold of the cloak. The genera Patella,* as now restricted, and Chiton afford examples where the branchiæ, in form of a cord composed of pyramidal processes, or of close-set and parallel transverse leaflets, encircle the body more or less completely, lying in a furrow between the foot and cloak, and merely covered by the prominent margin of the latter. In an order which Cuvier calls Inferobranches, these organs occupy a similar position, but limited often to one side of the body; while, in the Tectibranches (an order of which Aplysia may be selected as the type) the gills, almost free, and like some miniature arbuscle, occupy a position on the back, where they lie, scarcely hidden, under a moveable corneous lid that sits in the centre of a hollow formed by the large and muscular dorsal fin, intended apparently to collect the water as in a crater, that it may not pass away too rapidly, and until it has thoroughly penetrated the intricacies of the branchial apparatus.

The mollusca with internal branchiæ are more numerous than the preceding; for some Pteropoda, the greater number of the Gasteropoda, all the Cephalopoda, and all the acephalous tribes† are thus circumstanced. The various modifica-

the digestive function; but their branchial character is established by Souleyet (*Reports on Zoology*, p. 426), and by Hancock and Embleton. Vibratile cilia, distributed over the entire cuticular surface, aid their function.—*Ann. and Mag. N. Hist.* xii. 236.

Messrs. Hancock and Embleton say:—"The function of respiration we believe to be performed by the whole surface of the skin, including the papillæ; the skin of the back and of the sides between the papillæ, and the entire surfaces of these latter organs, present the phenomenon of ciliary vibration. The papillæ we regard as one modification among many, of increasing the surface for a respiratory purpose, and thus are to be regarded as a specialized breathing apparatus, to which the rest of the skin is subsidiary."—*Ann. and Mag. Nat. Hist.* ser. 2, i. 103.

"Now the whole, or nearly the whole of the blood that passes to the auricle of the heart comes, as we have shewn, in the section on the circulatory organs, directly from the skin, and as we know that the blood thus circulating in the skin and papillæ is separated from the oxygenated water of the surrounding sea, by a very thin layer, in the papillæ by an exceedingly delicate membrane, we have little hesitation in saying, that it is in the papillæ essentially, and in the rest of the skin secondarily, that the function of arterialization of the blood is carried on previously to the return of that fluid to the heart."—*Ibid.* 104.

* Blainville, however, maintains that Patella is pulmoniferous.—*Manuel*, p. 125.

† Lamarck considers the branchiæ of bivalves (Conchifera) as properly external (*Hist. Nat.* v. 417); and this view of their position is plausible, more particularly when the cloak is open in front.

tions of them in the remaining Gasteropoda have been already noticed slightly in the outline I gave you, in an early letter, of the Cuvierian system: but there is one family which, because of its greatness, may not be passed over in this place, — this is the Pectinibranches,— an order that includes almost all the marine turreted and convolute* shells, and a few which are found in fresh water. In it the branchial cavity has a position similar to that in the Pulmonifera, on the upper and fore part of the back; to wit, where it is protected by the body of the shell; but its walls are not smooth and even, like those of the pulmonary cavity, but folded into neat and regular plaits or ridges, that lie parallel to one another, like the teeth of a comb (whence the name Pectinibranches), and often part on each side from a central stalk formed by the trunks of the bloodvessels, in the same manner that the barbs of the web of a quill depart from the shaft. The water obtains ingress to this cavity, in such Pectinibranchia as inhabit shells with entire apertures, by a large slit on the side above the collar; and in shells with interrupted or beaked apertures, by an imperfect siphon that lies in the canal or emargination, and that is formed by a prolongation and duplicature of the cloak.

The gills of the Cephalopods are placed within their muscular sac, to which they are attached by their bases only in the Nautilus, but in all the naked genera a thin fibrous membrane connects the fleshy stem of each gill to the contiguous surface. In the Nautilus there is another remarkable peculiarity: it has four branchiæ, a larger and smaller one on each side, while all other Cephalopods are dibranchiates. The branchiæ present an elongated pyramidal figure with their apices directed forwards. "They are composed of a number of triangular vascular laminæ extending transversely from each side of a central fleshy stem, having an alternate disposition: each lamina is composed of smaller transverse laminæ, which are again similarly subdivided; the entire gill thus exhibiting the structure called by botanists "tripinnate," by which an extensive surface is afforded for the minute division of the branchial vessels."†

* Sir E. Home asserts that the lobes of the mantle which cover the shells of the cones and cowries are the respiratory organs of the animal (*Comp. Anat.* i. 55); but this is a mistake; they are truly pectinibranchial.

† Owen in Cyclop. Anat. and Phys. i. 542. See also Cuvier, Mem. i. 20.

The branchiæ of the bivalved mollusca are always placed between the body and its cloak, the folds of which being, in many of them, altogether separate in front, admit the circumfluent water very freely; but when these folds are soldered together at the edges, as they often are, the water is imbibed through a branchial siphon formed by an elongation of the cloak, and extruded at the posterior end of the shell; and the effete fluid is expelled again through another or anal siphon,—the common excrementitious tube, which, in general, is altogether like the other, and occupies the same position.* All bivalves which burrow in the sand or mud are furnished with these siphonal tubes. They are either separate or they are bound together in a common sheath; and their capability of elongation is always in exact accordance with the depth of the furrow of the mollusk: — if this merely covers itself with the soil the tubes are short and little extensible,—if it burrows deep they are made protrusile to the requisite extent. Their use is to keep up a communication between the animal and the superincumbent water, and the interruption of that communication would have the same deadly effect as the deprivation of air from any terrestrial animal. To prevent this death, and to allow a free flow of water unto them, there are always holes in the sand corresponding to the apertures of the tubes; and you must further notice that these apertures, more especially the branchial one, are encircled with a series of tentacular filaments that prevent the ingress of all noxious matter, and strain the water of respiration if

* This is the view generally received by malacologists, but Mr. W. Clark, an excellent observer, affirms that the circumfluent water enters by both siphons, and is also expelled through both of them. "I have little doubt that the water, required for buccal and branchial uses, in the mollusca with closed mantles, is received through both the posterior apertures, anal and branchial as they are called; and probably at their bases there is an internal communication, thus allowing the water from both to pass into the great cavity of the branchiæ, to bathe them, and for sustentation of the animal; and after these functions are fulfilled, it is in like manner expelled from both orifices, and often simultaneously, as may be seen in any of the Pholades, Lutrariæ, or Myæ." *Ann. and Mag. N. Hist.* ser. 2, iii. 453.—These views of Mr. Clark are controverted by Mr. Alder and Mr. Cocks, who maintain the accuracy of the ordinary statement. Lib. cit. iv. 50 and 55. Mr. Clark's observations coincide with those of Spallanzani, made on Ascidiæ; and in reiterating them, Mr. Clark says;—"The assumed regularity of the admission and discharge of the branchial currents is a sad mistake; nothing can be more irregular, capricious, and uncertain; they depend entirely on the volition, habits, and wants of the animal, and are often suspended for weeks in Kellia rubra, and twice in every twenty-four hours in the mussels and numerous Gasteropoda inhabiting the higher levels of the littoral zone."—iv. 143.

turbid.* If you find a bivalve which has not these tubes, or some analogous organization, you may safely conclude it to be a dweller on the surface.

In the great majority of the Bivalves the gills are in the form of large semilunar or quadrangular leaves that embrace the sides of the body, whence the mollusks are often called the lamellibranchiate.† There is a pair of these membranous leaves, often of unequal size, on each side, and each leaf is joined to that which corresponds to it on the opposite side at the dorsal margin; but in front they are usually separate: they are broad and lamelliform, are finely and regularly striated across, and sometimes appear punctulated in the intervals of the striæ. Each leaf, according to Blainville, is itself formed of two layers which leave between them a free space, divided by numerous triangular partitions into a great number of vertical cells open to the dorsal margin. These layers are constituted by two series of parallel vertical vessels united by others which cross them; one of the series being formed by the ramifications of the branchial artery, and the other by those of the vein. These minute ramifications can be ultimately traced to two great trunks which run along the back of the branchial leaf, one (the arterial) trends away to the auricle of its own side, to pour into it the renovated blood, while the other is the large vein from which the venous branchlets have departed.‡ "In

* Ann. des Sc. Nat. n. s. iii. p. 197. When the siphonal tubes are disunited, the respiratory one is the longest, and this is also the case when they are partially united. In a few cases, the branchial siphon is alone developed.

† Bojanus, Professor at Wilna, in an elaborate memoir published in 1810, and republished in the Journal de Physique, for 1819, has maintained an opinion, first mooted by Mery, that these leaves have no relation to respiration, but are ovaries, in which the eggs are maturated; while the true lung is an organ of a brown glandular appearance placed in a sac between the pericardium and the supposed branchial laminæ. The opinion has been very satisfactorily refuted by Blainville.

‡ Manuel, p. 128. Such of our readers as are interested in the structure of molluscous animals, will not be displeased at the length of the following extract from Carus:—"It is to be remarked, farther, of the large branchial laminæ of the fresh-water mussel, that both pairs consist of an intertexture of vessels arranged in a rectangular latticework, and covered by a delicate membrane, whilst the two external are distinguished by a structure which merits a particular description. Above each external lamina of the gills is a duct, proceeding from the posterior part of the foot towards the anal tube, long ago described as an oviduct by Oken, and having on its lower surface a long row of openings placed transversely, and forming the entrances to the cells, or compartments, of the gills themselves. These compartments are all arranged vertically in the gill, and separated from each other by partitions; they appear as though they originated from the mutual recession of the two

several genera, as the Arcadæ and Pecten, the branchial vessels, instead of being connected parallel to one another within the thickness of a common membrane, continue unconnected through their entire length, and they are thus formed of a great number of extremely delicate filaments attached by the base within a membranous pedicle, in which the branchial veins pursue their way towards the auricle. In a great many families and genera the branchiæ of one side have no communication with those of the opposite side; in some others, however, as in the genus Unio, the four branchial laminæ meet under the foot, and the whole of their vessels empty themselves into a venous sinus of considerable size."*

The Brachiopods, you will remember, derive their name from the fringed and curled arms which they can evolve beyond the compass of their valves; and some comparative anatomists have supposed that, whatever other use they were of, was combined that of aerating the blood. The opinion of Cuvier was different; and the beautiful dissections of Mr. Owen have proved that the true branchial vessels are ramified, in rich profusion, upon the inner surface of the lobes of the mantle, which are consequently the chief, if not the sole respiratory organ. "In this profuse distribution of vessels over a plain membranous expansion, we perceive the simplest construction of the water-breathing organ, or *branchia;* and, while it proves the close affinity of the Bra-

membranous surfaces of the gill, which remain connected only by the vertically disposed vessels that give rise to the septa; they serve for the reception of the ova, which, coming from the ovary placed within the foot, and not by any means formed in the gill itself, are, however, lodged there; and there receive their farther developement, as in a uterus. This is a remarkable instance of the connection between the sexual and respiratory functions."—*Comp. Anat.*, vol. ii. p. 148, 149, trans.—See also, ADANSON *Senegal*, pref. Liv.

* Deshayes in Cyclop. Anat. and Phys. i. p. 699. Mr. Garner's sketch of the variations of the branchiæ in the Lamellibranchiates is very interesting.—CHARLESWORTH'S *Mag. N. Hist.* iii. 169.

In the genus Solenomya, Lam. there is a singular anomaly in the structure of the branchiæ. "Branchiæ duo non quatuor, non lamelliformes, sed pectinatæ vel potius pennam exacte referentes, lamellis transversis perpendicularibus, carina media corpori per totam longitudinem adnatæ, versus apicem ope ligamenti."—PHILIPPI, *Mol. Sicil.* i. p. 16.

M. Valenciennes has observed, that the Lucinidæ and Corbis possess only a single branchia on each side of the foot and viscera; and, at the same time, the labial palpi, or accessory branchiæ, are all four wanting.—*Ann. and Mag. N. Hist.* xvi. 43. FORBES and HANLEY, *Brit. Moll.* ii. 42.—In Pholadomya and Anatina, Professor Owen had previously demonstrated that the two lamellæ of the same side are so united, as to appear like a single gill.—*Lect. Inverteb. Anim.* 283.

chiopoda to the Ascidiæ, it presents, at the same time, a beautiful analogy with the elementary forms of the air-breathing organ, as it exists, for example, in the pulmoniferous Gasteropods." *

The naked acephalous mollusca (Tunicata, Lamk.) have two, and only two, orifices in their outer tunic, which very often open on the tips of two tubular projections, or papillæ, placed near one another. By one of these,† which is usually the highest, and encircled within its rim with one or two rows of slender tentacular filaments, or furnished with a valve, the water necessary to respiration flows into a large visceral sac, which, while it seems in part to perform the functions of a crop, affords ample space for the display of the aerating blood-vessels. The water, after being breathed, is in general expelled at the same orifice by which it was sucked in; and, notwithstanding that the observations of several naturalists seemed to prove the contrary, Cuvier was nevertheless inclined to conclude, from his anatomical investigations, that it could not possibly be expelled from the other, which is the vent. The conclusion is only partially correct, for it would be erroneous were we hence led to infer that the animals cannot eject any of the contained water from the vent. The water which distends the body of a healthy submerged ascidian flows into it simultaneously by both orifices in a current so still that no stream is observable. Lister was well cognisant of this fact; and Reaumur states expressly, that the water enters at times, and is driven out by either of the siphonal apertures.‡ Spallanzani has described the phenomena, in our opinion, more accurately than any other observer.§ Dr. Coldstream says: "It has

* Owen in Zool. Trans. i. 154.—Also p. 148.

† In all the compound mollusca, the branchial orifice of the component individuals, tends always to approach to the circumference of the system, as the anus does as invariably to the centre.—*Savigny.*

‡ Hist. de l'Acad. Roy. des Sciences, 1710, 588.

§ "In my various excursions on the sea, I have observed that it contains many animals, which, absorbing the water by their mouth, produce a small vertiginous current, that runs into it. The animal in question has not this power. The water enters it almost insensibly, by occupying gradually the internal space which was empty. This I perceived by making use of the lens, but more distinctly by tinging the sea-water with cochineal, as the animal will live several hours in this water without any apparent injury. The red particles of the tincture will then be seen slowly to enter the two apertures with the water, gradually filling the vacuity of the animal without the appearance of a current of any kind. After some time, the slow motion of the particles ceases; that is, when the internal cavity is completely filled with the coloured water, which I could cause to issue from the apertures at pleasure, by pressing the Ascidia between my fingers.

been doubted whether the Ascidiæ, in contracting their tunics, expel the water through their anal as well as through their branchial orifices. I have distinctly seen this species (Ascidia prunum), as well as others (in particular the A. intestinalis), propel currents of water through both orifices at every contraction of the tunics; that from the anal orifice being almost as strong as the one from the mouth of the branchial sac."* But, indeed, long before this, and even previously to the publication of Cuvier's memoir, Carus had detected "a lateral opening furnished with valves," in the sac, by which the water might have egression, and which, says this most ingenious anatomist, satisfactorily explained how these animals have "the power of rejecting the respired water not only through the mouth, but also through the anus."† I believe there is an error in this anatomical explanation. Mr. Garner, who knew well that the water entered the body by both orifices, says, that by one it "enters the respiratory sac, and by the other it is drawn into the external meshes of the branchiæ. The water drawn in by each opening must make its exit by the same. Those writers who say the contrary must be incorrect, unless the water pass through the stomach and intestine." In like manner the water enters the respiratory organs of some bivalves (*e.g.* Teredo, Pholas, Mya, and Solen) by both siphons."‡

The branchial cavity itself is a large flattened sac, which varies greatly in respect of extent, depth, and form. Sometimes, as in Ascidia clavata, it occupies only a small portion of the length of the body; oftener, as in Ascidia microcos-

"If, when all the water is thus brought out of the Ascidia, the animal be immersed in that contained in a vessel, in such a manner, that only one of the apertures be under water, it will fill itself completely by that, whether it be the upper or the lower. It is evident from this, that there is a communication between the two apertures; of which I also had another proof equally demonstrative, in the air which issued from the lesser aperture, and which, by means of a small tube, I could, without force, cause to pass into the greater, and *vice versâ*. When, besides, I kept one of the apertures closed while I blew into the other, the animal swelled like a bag, and the air found no vent.

"It appears therefore certain, that the upper aperture is the mouth of the animal, and the lower the anus. In fact, by the latter, I have frequently seen the Ascidiæ discharge matters which had all the appearance of being excrementitious. This lower orifice, likewise, communicates with another channel, or organ, as we shall see presently."—*Travels in the Two Sicilies*, iv. 264-6.

The species on which Spallanzani made his observations is defined:—"Ascidia coriacea lævis subdiaphana, apertura superiore octagona, humiliore heptagona."—p. 274, pl. 10, fig. 1-7. I believe it to be the As. prunum of Linnæus. It is not figured by Forbes and Hanley, yet I feel certain that it is a British species.

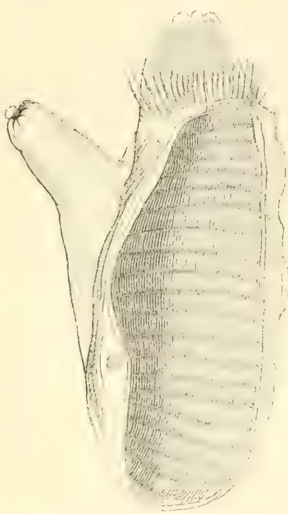
* Edinb. Phil. Journ., October, 1830, p. 240.

† Com. Anat., ii. 146, trans.

‡ Mag. Nat. Hist. n. s. iii. 170.

mus, it occupies all the length and the breadth of one of the sides, and the rest of the viscera occupies the other side: then its form is oblong, oval, or rectangular. Sometimes, as in Ascidia mammillata and monachus, after having descended even to the bottom of the outer tunic, it bends upwards until its base is at the middle of its length, and looks towards the entrance. In the latter case, the parietes have the greatest extent. In general these are smooth and without plaits; but in some species, and, as it would appear, in all those which have a coriaceous outer cloak, they are creased into deep and regular folds, the first vestiges of the four branchial leaves of bivalves.

Fig. 48.



Phallusia sulcata of Savigny, opened.

Whatever may be, however, the shape and general disposition of the sac, the texture of its inner parietes remains essentially the same, and is so very remarkable that several authors, who knew not its purport, have expressed astonishment at its beauty. It consists of an infinity of little vessels which cross one another at right angles, and thus weave a network with quadrangular meshes (Fig. 48), that are again subdivided by vessels of such tenuity that they elude the unaided vision, and require the microscope for their discovery. With a little attention it may be perceived that the vertical vessels come from the transverse vessels, and that these are connected by their extremities to two great trunks, also vertical, which occupy one of the sides, or rather the edges, of the sac; and it is natural to conclude that one of these trunks is the artery, and the other the branchial vein.*

The meshes of this branchial network are generally, as I have said, nearly square and uniform, yet in the different genera there is exhibited a considerable variety of patterns, some of which you have here copied from the beautiful plates of Savigny. Fig. 49 exhibits a small portion of the

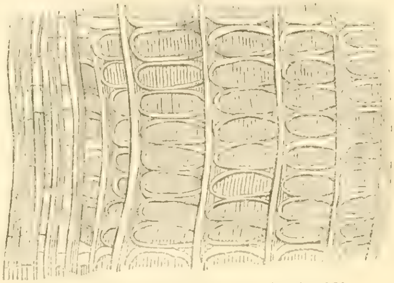
* Cuvier, Mem. xx. 11, 12.—Spallanzani mistook the vessels for minute muscles,—"the longitudinal to shorten by their action the length of the body, and the transversal to contract the breadth."—*Travels,* iv. 269.

branchial surface of the Ascidia pedunculata (Boltenia ovifera, Sav.), highly magnified, and is an example of its usual

Fig. 49.

Pattern of the branchiæ in Ascidia pedunculata.

Fig. 50.



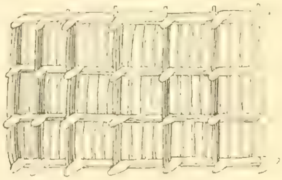
Pattern of the branchiæ in Ascidia mytiligera.

and least ornamental conformation; in the Ascidia (Cynthia, Sav.) mytiligera the meshes are elliptical (Fig. 50); and they have the same form in many other species, more particularly in the compound families, or those in which a great number of individuals are united together in a common system. (Fig. 51). Again, in some genera, of which

Fig. 51.

Pattern of the branchiæ in Pyloclinum hesperium.

Fig. 52.



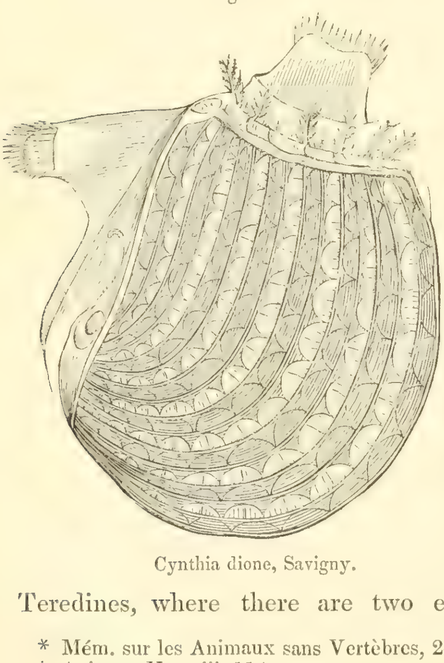
Pattern of the branchiæ in Phallusia sulcata.

the Phallusia of Savigny is one, there is a small conical process at each angle of every little square (Fig. 52); but it is in the Cynthia Dione that the most remarkable modification of this structure appears. Here the branchial tissue is not continuous upon the folds of the sac, but interrupted, at equal distances, in a manner to resemble a series of very regular festoons. Each fold has a second at its base, which is not free like itself, and of which the points of fixture correspond to the intervals

which separate the festoons. The whole of the plaits are twenty-eight, fourteen on each side, and they are margined by an equal number of great longitudinal vessels. The vessels which compose the tissue are excessively fine; the transverse, however, less delicate than the others, and not so closely set, accommodate themselves very well by their curvature to the outline of the festoons. This description, I feel, needs the aid of Savigny's figure, of which I gladly avail myself, and I am certain that in few other creatures will you find a structure more wonderfully fashioned. (Fig. 53.*)

Although the branchial tissue apparently covers the whole inner surface of the sac with a continuous network, yet it is really divided into two halves by a furrow in which the trunks of the blood-vessels lie; and this structure becomes obvious in some families where, as in Pyrosoma, the interspace is considerable; and is still more remarkably obvious in the Salpæ, in which, in fact, the branchial vessels are not disposed on the walls of the sac, but occupy the margin of two narrow linear leaflets of very unequal lengths that lie across the cavity. These are formed by a duplicature of the inner tunic, and the superior margin is garnished with a close series of little vessels which run parallel to one another in a transverse direction; a form and disposition which, says Lamarck, has very little analogy with what is regarded as the respiratory organ in the Ascidiæ; † but which, on the contrary, Carus seems to think is just the link that connects these with the bivalves, "appearing to constitute the transition from the Ascidiæ to the Teredines, where there are two elongated branchial la-

Fig. 53.



Cynthia dione, Savigny.

* Mém. sur les Animaux sans Vertèbres, 2de partie, *passim.*

† Anim. s. Vert. iii. 114.

minæ above the intestine and within the tubular cloak, to which the water has access and egress by means of two tubes placed at the posterior extremity of the body."*

Let us, before proceeding, reflect a moment on that wonderful diversity in the structure of the same organ here exhibited to us in one class of animated beings: it is a fine example, among many, of that variety in which the Creator of all has seen good to indulge in the production of his works, as if, to use the words of a favourite author, He "willed to shew those whose delight it is to investigate his works, by how many varying processes he can accomplish the same end."† I see in it also a proof, that neither external and physical circumstances, nor self-born desires, have that great and almost creative influence in framing or modifying animal structures which many imagine they have; for here are before us a crowd of animals whose soft bodies, it will be allowed, are as susceptible of changes, or of being moulded to one type, as any animals can be, and the uniformity of whose nervous system seems to prove that their faculties and desires are much on a par; yet, if we select any large family from among them, we shall find them living in the same seas, and in the same depths, and in the same latitudes, and on the same food, and all breathing the same air; but, so far from showing a perfect agreement in their exterior organs, on which these causes are said to operate so efficiently, we find all is diverse, whether we look to the position, the form, or the structure of the organs. These are now, my friend, such as they were when the creatures

* Comp. Anat.Trans. ii. 147.

† "Most of the Ascidiæ are coarse, unsightly, deformed-looking animals, utterly void of that external symmetry and beauty, rendering many of the tenants of the waters so interesting. Nor is it in this only, that they should fail to attract the spectator's notice. They testify neither instinct, action, nor motion, nor even the symptoms of life, farther than slight enlargement and reduction of size, together with contraction and expansion of the two tubular orifices of the body. No sensible alteration follows abstinence or repletion; the external form undergoes scarcely any modification from health or disease; even the lapse of time, that universal consumer, seems hardly to make any impression on the shapeless mass, which is rooted immoveably from the first moment, on the same spot to vegetate, live, or die.

"Such is the case, with but few exceptions, during any ordinary or reasonable period, that may be occupied in observation.

"Yet, let us recall what is disclosed when this rude object is stripped of its external integuments, from which some of the germs may be withdrawn, almost as from a bag. How complex the structure thus displayed; what a wonderful arrangement of muscular, respiratory, circulating, secretive, and digestive organs, adapted for discharging the vital functions, all proving the handiwork of the Great Architect, as directed towards a common end."—Sir J. G. Dalyell.

came into existence from Infinite Wisdom, perfect, and complete, and immutable; and, notwithstanding all their variations, ever suited with special adaptation to the element and the place they were fore-ordained to inhabit. "Their forms are His special invention and construction, and their principle of life is also His special and communicated gift," is the just conclusion of an historian eminently distinguished for his learning, his good sense, and his piety.*

Now, the distinction which has been drawn between the Mollusca with lungs and gills, however anatomically correct, is not always physiologically true; for although I am not cognisant of any pulmoniferous species that can breathe water,† or ever does so voluntarily, yet there are many branchiferous ones that can and do respire the uncombined air. A great number of bivalves are alternately submerged and exposed to the air, according to the fluctuations of the tide; but then the animals are covered up with a wet soil, or the concavity of the lower valve enables the animal always to retain some moisture around its gills, and I believe they do not open their shells freely unless when covered with water.‡ Of the Cephalopods the Octopoda are said to come ashore frequently, and live among the rocks for days together; and the Pteropods and the naked Gasteropods in general love to swim at the surface in calm weather, particularly at the time of sunset, apparently to enjoy the respiration of a lighter and more oxygenated medium. There are other Gasteropods with gills which pass so large a portion of their term of life completely out of the water, that they seem to merit the appellation of amphibious. The most remarkable of these is an Australasian species of Neritina, which loves to forsake its native rivers or ponds for the green shade of the trees, amid whose foliage it is found abundantly. The Patellæ and the Littorinæ are also good examples. Our common species of the latter genus seem, indeed, to prefer spots where they can be covered only at high water, and I have seen myriads of them, when

* Mr. Sharon Turner. His Sacred History of the World, from which the quotation is taken, I earnestly recommend to the attentive perusal of students of natural history.

† Peron seems to have believed that a species of Onchidium (a pulmoniferous genus) found on the shores of New Holland, lived always in a state of submersion, but there is no doubt of some mistake here.—See Audouin and Milne-Edwards in their Litt. de la France, i. 118.

‡ Kellia rubra spends the greater portion of its life out of the water, and is often for at least a fortnight uncovered with it.—See Clark in *Ann. and Mag. N. Hist.* Ser. 2, iii. 455, and iv. 144.

young, clustered in hollows of rocks that were many feet above the highest tides. Still, their respiratory organs are, as they ever have been, branchial; nor does it seem easy, on the Lamarckian hypothesis, to account for their non-improvability: why these shell-fish, so fond of air, have not acquired, by their residence in it, the lungs of the snail, and betaken themselves to the land; why their shells have not become lighter to enable them to move with more alacrity; and why their eyes have not risen to a higher elevation than the base of the tentacula, that they might scan the landscape and avoid its perils. The habits of the Chitonidæ are similar to those of the Littorinæ. "These animals," says the Rev. Mr. Guilding, "frequent the rocks and stones of the sea-coast, and are distributed nearly over the whole globe. Many of the species are constantly under water, while others ascend above low or even high-water-mark, spending the day exposed to the hottest sun, or selecting a resting-place which is only occasionally moistened by the rude and restless surf. In Chitonellus and Cryptoconchus there are certain minute organs on the zone, which bear a strong resemblance to the spiracula of the annulose animals. From their habit of quitting the watery element, like many of the Turbinidæ, I once supposed that the organs for the aëration of the circulating fluid might be of a compound nature (pulmono-branchiati). It is, however, far more probable (as in the case of some crustaceous genera which I am now investigating) that this process is capable of a diurnal or a temporary interruption, or that the branchiæ, so long as they are kept moist, and shielded from atmospheric influence, may perform their functions, though much more slowly."

It is probably this capableness of protecting the branchiæ from the drying influence of the air that enables even such mollusks as habitually live submerged to survive their removal from the sea for a very considerable time, so that they may be thus carried to the greatest distances without injury, while any attempt to carry them, or to preserve them, in sea-water would have failed, without a care to renew the water that could seldom be bestowed. The death in experiments of this kind does not ensue from the abstraction of oxygen from the water, but from its corruption; and hence you will find that, if not mechanically prevented, the animal will creep from the poisoned bowl to expose itself to a slower death in an element which it cannot breathe. But what you would little anticipate to hear, fresh water is to these pelagic molluscans even a deadlier poison, and quicker

in its operation, than ardent spirits. Aristotle was aware of this fact, for the Purpuræ, he tells us, died in the course of one day in fresh water, although they could live fifteen days under the open atmosphere. But the poison works in general much more rapidly than is here stated, and we have rarely found a truly marine species resist its influence above a few minutes,—some not as many seconds. You will perceive in this fact the ordained means of retaining these animals, in general carnivorous, within their natural parks, if I may so speak, and the surest of all guards against their inroads on the defenceless tribes which inhabit large rivers and lakes. But to occupy the ground that lies between these two tribes —the marine and lacustrine—we find another race created, whose delight is to dwell in brackish water,

"Or on the beached margent of the sea,"

and who can bear, with comparative impunity, either the river or the purer sea. Several Littorinæ and Rissoæ are in this condition; as well as the common mussel, the cockle, and some littoral Tellinides. The Potamides, a marine genus, is often found at the mouths of rivers; and Rang has found at the isle of Bourbon, in a fresh water tank, not far removed, however, from the shore, Pintadines and an Aplysia living in society, under stones, with Neritinæ and a Melania.* In South America, near Rio de Janeiro, Mr. C. Darwin found a Limneus in great numbers in a lake into which, the inhabitants assured him, the sea annually, and sometimes oftener entered, and made the water quite salt. M. Gay has stated that he found, in the neighbourhood of Rio, the marine genera Solen and Mytilus, and the fresh water Ampullariæ, living together in brackish water.† Facts of this kind ought to be kept in remembrance by the geologist, but yet not with the fixedness of gaze that would rather blind than guide him.

And *apropos* to this hint:—In some strata of comparatively recent formation, marine and fluviatile shells have been found commingled, and some have made a noise about the discovery as if it were one which led to important deductions; nor need we dispute its value. Beudant was induced by the discovery to institute some experiments with the view of determining whether or not marine mollusca could not, by adopting proper precautions, be gradually habituated to fresh water and enabled to live in it, and if fluviatile mollusca could not, on their side, be accustomed to the sea; and his experiments incline him to think this might be done,—

* Manual, p. 47. † Darwin's Journal, iii. 24.

but you may rely upon it that it could not be done, or done only with a few, and to a very partial extent. A discovery of M. de Freminville, quoted in Beudant's support, does not more than vindicate my caution. This zealous and intelligent naturalist, in a letter to Brongniart, says, "The weakness of the waters of the Baltic Sea is still more perceptible in the gulf of Livonia than any where else: it is such that the mollusca of fresh water live there very well, and I have found upon the shore Unios, Cyclades, and Anodontæ living *pêle mêle* with Cardia, Tellines, and Venus,—shells which usually inhabit the saltest waters."* This is not exactly the case; there are species in all these genera which are littoral, and do not dislike a diluted water. Mr. Garner made experiments more conclusive than those of Beudant, and I have no doubt of the soundness of his conclusions:—"It would seem from this," he says, "that although perhaps some of these animals may bear a slight change as to the freshness or saltness of the water (and perhaps those species inhabiting estuaries do so more than others), yet this capacity must be very limited. The Cardia, Mactræ, Amphidesmæ, &c., found in marshes on the coasts, become diseased and die when the water becomes concentrated by evaporation, or when it loses its saltness by mixture with fresh. The Mytili found in fresh water docks, are probably fresh water species brought from foreign rivers, and which, perhaps, have survived their immersion in salt water during their voyage, by having kept their valves constantly closed; some species of Mytilus are known to inhabit fresh water. It appears certain, that in those rivers where the Uniones, Anodontæ, and Cyclades abound, they cease to be found where the water becomes salt."†

But one geo-conchologist, at least, would have us to carry our credulity a little further than even M. Beudant. I have already told you that the common people of Barra believe that their sandloving and foodful cockles are born and bred in the fresh springs of their hills, and come down to the sea to receive the virtue that makes them so large and so savoury.‡ Our savant reverses the fable; and he finds the

* Journ. de Physique, lxxxix. p. 80.

† Charlesworth's Mag. N. Hist. iii. 302-3.—In the "British Mollusca" of Messrs. Forbes and Hanley, some facts corroborative of Mr. Garner's views will be found.—See in particular, vol. i. 172.

‡ Buchanan, in his history of Scotland, tells the tale, "On the north side of Barra, one of the Western Isles, stands a verdant hill, from whose summit springs a fountain of clear water, the source of a river, which carries along with it to the neighbouring sea, certain small, but unformed animalcula, which appear in part, but indistinctly, to be a species of shell-

cockles, full grown and all alive, in the well-springs of a moor! At the meeting of the Wernerian Society on the 19th of November, 1825, Henry Witham, Esq., read, what is called by the reporter, "a very interesting paper," on the discovery of Live Cockles in *Cocklesbury* moss, in Yorkshire, distant about forty miles from the sea-coast. The Cockles were collected in considerable quantity: and Mr. Witham had the curiosity to eat some of them, which differed "but little in taste from the common cockle, unless it were that they seemed not quite so salt." The specimens exhibited left no doubt that the cockles in question were identical with the Cardium edule.* No story-teller could desire a more loveable disposition in his auditors than that of the philosophers who listened with interest to such a communication; but, unfortunately, naturalists are not less the subjects of a practical joke than your learned antiquaries. I need scarcely say that some wicked wag had carried the cockles to Cocklesbury-moss to hoax the worthy, benevolent, and zealous communicant.

fish, which we commonly call cockles. The part of the shore to which these are carried, the inhabitants call the great sands, because there, upon the ebbing of the tide, a sand-bank, upwards of a mile in length, is left bare, out of which large shells are dug, believed, in the neighbourhood, to be produced from that seed which the river brings down from the fountain, or at least, to have grown larger in the sea."

* Ann. of Philosophy, n. s. xi. 465-7.

AN APPENDIX TO LETTER XVI.

OF SPECIES BELONGING TO THE SAME NATURAL GENUS INHABITING ESSENTIALLY DIFFERENT SITUATIONS. BY JOHN EDWARD GRAY, ESQ., F.R.S. &C.

*** Reprinted from the *Philosophical Transactions*, part ii. for 1835, with the consent of the Author.

The general belief that all the species of the same genus inhabit the same kind of situation, undoubtedly holds good with reference to most of the genera of shells; but many exceptions have already been observed, and we may anticipate that many more will be discovered as the natural habits of the different species become better known. In bringing together a number of these exceptions, I have been under the necessity of placing considerable reliance on the observations of others, who have noted in foreign countries facts similar to those which I have myself witnessed at home; but these observations have been chiefly collected from the works of Professor Nilsson of Sweden, of Mr. Say of the United States of North America, and of MM. Lesson, Quoy, and Rang of Paris, writers who, from their extensive knowledge of Conchology, are fully capable of accurately recording their observations, and whose statements may therefore be received as deserving of the most implicit confidence. It is moreover to be observed, that all their observations on this subject were made simply with the view of extending the knowledge of the history of the species to which they refer, and without reference to the establishment of any preconceived theory.

These observations may be classed under the four following subdivisions: 1st, where species of the same genus are found in more than one kind of situation, as on land, in fresh and in salt water; 2nd, where one or more species of a genus, most of whose species inhabit fresh water, are found in salt or brackish water; 3rd, where, on the contrary, one or more species of a genus, whose species generally inhabit the sea, are found in fresh water; and 4th, where the same species is found both in salt and fresh water.

Of the first of these classes the genus Auricula, as defined by Lamarck, may be quoted as a striking example. Of its species, A. scarabus and A. minima are found in damp places on the surface of the earth; A. judæ lives in sandy places overflowed by the sea; A. myosotis, A. coniformis, A. nitens, &c. (separated by De Montfort under the name of Conovulus,) are found only in the sea in company with Chitons, Littorinæ, and other truly marine shells; and the South American species which I distinguished some time since under the name of Chilina, including A. Dombeyi of Lamarck, and A. fluviatilis of Lesson, inhabit freshwater streams, having most of the habits of the Lymnææ. This disparity of habitation has been in some degree overcome by dividing the genus into several, as noticed above; but the characters employed for their distinction are very slight, and species apparently intermediate between them are constantly occurring.

The genus Lymnæa has usually been considered as confined to fresh water; but M. Nilsson describes a species under the name of L. balthica, which is found "in aquâ parùm salsâ Maris Balthici ad littora Gothlandiæ et Scaniæ, &c. In maris juxta Esperöd fucis et lapidibus adhærens frequenter obvenit simul cum Paludinâ balthicâ et Neritinâ fluviatili;" and a second under the name of Lymnæa succinea, which is found on the shores of the sea near Trelleborg. All the species of Paludina and Bythynia which have fallen under my own observation are essentially fluviatile; but M. Nilsson refers in the paragraph above quoted to a species of the former genus inhabiting the sea. This may, however, like some of the smaller Paludinæ of Draparnauld, be truly a Littorina, having a horny and spiral, and not an annular operculum.

According to the observations of my sister, Mrs. Ince, of Mr. Benson, of MM. Quoy and Gaimard, and of M. Lesson, the Indian species of Neritina, like the European, are found only in fresh water; yet M. Rang, in his Manuel des Mollusques, p. 193, states that the Neritina viridis is a marine species found on rocks covered by the sea at Martinique, and that a larger variety of this species is found in similar situations at Madagascar; General Hardwicke marks on his drawing of the Neritina crepidularis, that it was found in "saltwater lakes, April 1816;" and Say has described the Neritina meleagris of Lamarck (Theodoxus reclinatus, Say), as living both in fresh and salt water. This is most probably the species to which Mr. Guilding refers,* when he

* See Zoological Journal, vol. v. p. 33.

observes that he has kept Neritina for some time alive in a close vessel of salt water, which they appear to purify. The animals of some of the tropical species often quit the stream and crawl up the trunks of neighbouring trees, on which, like the species of Littorina, Planaxis, and Bulla, which creep up the rocks on the sea-coast, they attach themselves, and remain exposed to the influence of the sun. It may be added, that M. Rang has found Neritina auricula in brackish marshes near the sea in the Island of Bourbon, in company with Aviculæ and Aplysiæ; and I have little doubt that Neritina pupa inhabits the sea, it being uniformly brought to this country in company with marine shells.

Many species of Melania, as, for example, M. amarula, M. fasciolata, and M. lineata, are found in the freshwater streams of India and its islands. Mr. Say mentions species found in similar situations in North America; he also describes one (M. simplex) as found in a stream running through the saltwater valley near the salt-works, but does not state whether the water of the stream is salt or fresh. On the other hand, M. Quoy asserts that they are sometimes taken in brackish water; M. Cailliaud states that Melania oweni is found in brackish water; and M. Rang has found other species in the Island of Bourbon under the same circumstances with the Neritina just adverted to. The genus Melanopsis has the same habits; its species are often found in large inland lakes. I have myself received M. buccinoidea from the sea of Galilee; and Dr. Clark, in his Travels, vol. ii. p. 243, figures M. dufourii under the name of Buccinum galileum. The water of this lake, however, unlike that of the neighbouring Dead Sea, is, according to the statement of Fuller, perfectly fresh and sweet. M. Lesson, on the other hand, states that he found the Pyrena terebrans, regarded by M. de Férussac as a Melanopsis, in great abundance in brackish marshes in New Guinea, and at the Island of Bourou.

I am informed by Mr. Sowerby that some species of the fluviatile genus Cyrena are found in the sea on the coast of South America; but he thinks it probable that the part of the sea in which they are met with may be fresh, like certain parts of the ocean described by Dr. Abel in his voyage to China. It would be highly interesting to procure a verification of this observation. Similar phenomena may not be uncommon, for I have myself observed in Torbay a small space in the neighbourhood of Brixham, the water of which was of a different colour and much fresher than that of other parts of the bay. With reference to another species of the

same genus, Cyrena vanikorensis, M. Quoy observes: "Ne l'ayant pas trouvée dans les lieux marécageux, mais sur les bords de la mer, il est probable qu'elle vit à l'embouchure des rivières qui sont saumâtres à marée haute."*

The third class of cases, in which species of Mollusca that are generally found in the sea are taken in fresh water, is much more rare than the preceding. It is obvious that in such instances the animal must be possessed of the capability of adapting itself to the different characters of the two fluids. This capability exists in much more highly organized animals, such as fishes, many species of which constantly migrate from the sea and ascend the rivers to deposit their spawn; but in these cases it is the result of a regular and determinate habit, while in the Mollusca it appears to be entirely dependent on accidental circumstances.

In some marshes in the Island of Bourbon, in which the water is almost fresh, M. Rang has observed specimens of Aplysia dolabrifera in company with Neritinæ and Melaniæ.

The greater number of species of the genus Cerithium are truly marine, chiefly living in sandy bays, like our own Cerithium reticulatum. M. Lesson, however, found C. sulcatum, and Adanson the African species figured by him, in the pools of brackish water, sometimes overflowed by the sea, which are situated between the weeds and the belts of mangrove trees on the shore; and Mr. Say observes that the small species, called by him Pyrena scalariformis, but which is a true Cerithium, is found in great abundance in the fresh water of Florida Keys. He adds: "it is most certainly a freshwater shell, yet it is destitute of an epidermis."

The genus Bulla is also truly marine; but the Rev. Mr. Hennah some time since presented to the British Museum specimens of one of its species, resembling the Bulla hydatis, found by him in brackish pools on the coast of Chili; and Mr. Say has described a Bulla fluviatilis found by Mr. Aaron Stone deeply imbedded in the mud of the river Delaware.†

The Littorinæ, again, are all found either on the sea-shore or in the very brackish water of the mouths of rivers, except two, which, although described as Paludinæ by Pfeiffer and De Férussac, and formed into a distinct genus by Ziegler under the name of Lithoglyphus, agree with Littorina in every character of shell and operculum, and, as far as I can

* Voyage de l'Astrolabe, tom. iii. p. 516.

† See for this latter instance the Journal of the Academy of Natural Sciences of Philadelphia, vol. ii. p. 179.

ascertain from the descriptions, of the animal also. These are the Paludina fusca of Pfeiffer, and the P. naticoides of De Férussac: they are truly fluviatile.

These anomalies are not restricted to the univalves: bivalves have also their share. Thus, the genus Solen is generally and properly considered as marine; but Mr. Benson has lately discovered a species inhabiting the mud on the banks of the Ganges; and conceiving, from the nature of its habitation, that it ought to be separated from the common species, he has formed a genus for its reception under the name of Novaculina. On comparing, however, some specimens of the shell presented to the British Museum by Mr. Royle, I can scarcely distinguish it as a species from the Solen dombeyi of Lamarck, which is found on the coast of Peru; and I have two other species, very nearly related, one from the rivers of China, and the other from pools of brackish water on the coast of America. In like manner M. Nilsson has found his Tellina balthica, which appears to be little more than a variety of the Tellina solidula of our coast, in the brackish water of the shores of the Baltic. Avicula margaritifera, the mother-of-pearl shell, commonly found in the ocean, has been taken by M. Rang in marshes in the Isle of Bourbon, in the neighbourhood of the sea in which the water is nearly fresh. Specimens of Mya arenaria also are often found so high up the rivers that the water in which they live is brackish only during high tides. They are found, moreover, with freshwater shells on the coasts of the Baltic, while all the other species of the genus are found only where the water is quite salt.

By far the greater part of the species of Corbulæ are truly marine; but there is a large species of the genus, called by Dr. Maton* Mya labiata, brought with freshwater shells from the mouth of the Rio de la Plata; and this agrees in many respects with the fossil Corbula gallica, which occurs in what are called the upper freshwater strata of the Isle of Wight.

The transitions to which the oysters intended for the London market are exposed may be mentioned as an additional illustration. Many of these are collected in the sea on the coasts of Guernsey and of France, and are brought to situations in the mouth of the river where the water is merely brackish during the ebb of the tide, and where they are consequently subjected to the alternate action of salt and brackish water twice in each day. It is even affirmed

* Linnean Transactions, vol. x. p. 326, t. 24, f. 3.

that oysters can exist in water absolutely fresh; for in the Museum of the Bristol Institution there is a large group said to have been dredged up in a river on the coast of Africa where the stream was so sweet as to have been used to water the ship. To these shells are attached specimens of Cerithium armatum; and the person by whom they were presented to the collection stated that Cardium ringens was found abundantly in the same situation.

The genus Cucullæa, again, is universally considered as truly marine; but Mr. Benson has found in the Ganges a small shell belonging to it, regarded by him as an Arca, but, on account of its freshwater origin, formed into a new genus under the name of Scaphula.

On this subject I may observe, that I was some time ago informed that Arca senilis was found in the rivers of Africa in company with Galatea radiata: M. Cailliaud, however, assures me that this is by no means the case, the shells in question being found near the mouths of the rivers, but never in the rivers themselves.

One of the most decisive facts regarding the finding of the same species of shell in both salt and fresh water is noticed by Say.* Speaking of Theodoxus reclinatus, he observes, "I found this species in great plenty, inhabiting St. John's river in East Florida, from its mouth to Fort Picolata, a distance of one hundred miles, where the water is potable. It seemed to exist equally well where the water was as salt as that of the ocean, and where the intermixture of that condiment could not be detected by the taste." The shell in question is determined, by specimens which I received from my late friend himself (to whom science is so deeply indebted, and especially for his researches into the zoology of North America), to be the Neritina meleagris, obtained in such abundance from the West Indian Islands. Nilsson too, as before mentioned, has noticed the Neritina fluviatilis, which in this country is not observed to inhabit ditches in the neighbourhood even of brackish water, living on the coasts of the Baltic, in brackish situations, in company with Lymnæa balthica and L. succinea; and M. Rang found Neritina auriculata in similar situations.

According to the observations of Olivier, the Ampullaria ovata inhabits Lake Mareotis, where it is taken in company with marine shells found also in the Mediterranean; and I have lately received (dead) specimens from

* Journal of the Academy of Natural Sciences of Philadelphia, vol. ii. p. 258.

the locality indicated. The same species was found by M. Cailliaud in freshwater lakes in the Oasis of Siwah, where it is called Bozue, and eaten as food. It thus appears to be found both in fresh and brackish water. Two of the species referred to this genus by Lamarck, his Ampullaria avellana and A. fragilis, are truly marine; but they differ from the others in animal and operculum, as well as in the sinuated form of the outer lip of their shell.

The common cockle of the shops, Cardium edule, is constantly to be seen in the ditches of brackish water in the neighbourhood of Tilbury Fort, which gradually become more or less fresh in proportion to the quantity of rain that falls between the periods of opening the sluices. It is to be observed that the specimens found in this situation are rather thinner and more produced posteriorly than those usually found in the sea. The species in question is also, according to Nilsson, found in the brackish water on the shores of the Baltic, but I am not aware whether or not it is there subject to a similar variation in form. Nilsson observes, however, that the marine species found in those localities are generally smaller than those found in other situations.

From this list of exceptions to the general rules which have commonly been regarded as decisive of the localities inhabited by recent shells, and of the nature of the deposits in which the fossil species are found, it is manifest that those rules cannot safely be made use of for practical purposes without considerable reservation.

J. E. Gray.

LETTER XVII.

ON THEIR FOOD AND DIGESTIVE ORGANS.

In reference to the present subject, I shall divide molluscous animals into three classes:—1st, those which take their food in a liquid form, or suspended in water; 2ndly, those which are more properly carnivorous; and, 3rdly, those which feed on vegetable matters.

To the first class all the Mollusca tunicata belong, and the tenants of the bivalved shells. There is no one of either of these extensive tribes which is furnished with any organ adapted to the capture or arrestment of prey, or with jaws or teeth to tear and masticate it; and, as the greater number are immovably fixed to one spot for life, or are only capable of such motions as raise or depress them in their furrows, they are necessarily content to await what moist nutriment is brought within reach of their lips by the waves and currents of the circumfluent waters. The Tunicata have the power of enlarging the capacity of their large branchial sac; and it is probable that, during this action, a portion of water rushes in, with all its contained animalcules and microscopic vegetables, which serve for the food of the individual. Sir J. G. Dalyell says that the food of the Ascidiæ "seems to consist of what may be eliminated from muddy solutions. Quantities of mud suspended in water are evidently absorbed and long retained; they visibly fill the intestinal cavities of those species whose transparence exposes the interior. If the clearest sea-water be rendered turbid, it is speedily purified by the secerning operation of internal organs, serving to select the nutrition, while the residue is rejected, to be discharged in rolls or cylinders." * What they select from this mud are the infusorial vegetables with which it is loaded. I have found in the stomach of the Ascidiæ, as also in the sac of some of the compound and smallest species (Alcyoneæ) myriads of very minute corpuscules, which the microscope showed to be Diatomaceæ of various genera.† Löwig and Kolliker found that the

* Rare and Remark. Anim. Scot. ii. 140.

† Dr. Dickie has given the following list of Diatomaceæ which he found in the stomachs of different Ascidiæ taken near Aberdeen.

Tunicata lived entirely upon vegetable organisms. The contents of the stomachs of the Phallusiæ, Clavelinæ, and Diazonæ, examined by them, consisted of particles of florideous algæ, which had probably found their way there by chance, and a great quantity of microscopic plants of low position in the series, species of Navicula, Frustulia, Baccilaria, Closterium, &c.* I think that I have also detected the remains of entomostracous insects in the sac of some Tunicata; and Savigny, who has frequently made the same observation, has found in even the compound species, crustacea of a higher order and greatly larger dimensions. The latter, however, as Cuvier thinks, may have entered against the will and to the prejudice of the mollusk; for he has observed the delicate texture of the viscera torn and ruptured by such rude ingesta.†

Of the Tunicata there are two families: one, Alcyoneæ, or the compound, in which numerous individuals, generally of very small size, are united together, and, as it were, immersed in a common somewhat gelatinous mass; and another, Ascidiæ, or the solitary, in which every individual is single and separate, and of much greater magnitude. In both of these families, there is a circular aperture, raised a little above the surface of the common integument or sac, and capable of being shut or opened, more or less widely, at the pleasure of the animal. The rim of it is sometimes plain, and sometimes cut into four, six, or eight equal segments; and within the orifice there is, in very many of them, a fringe formed of one or two rows of delicate cilia, which I have observed, in the Ascidia rustica, to be in con-

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Epithemia sorex	Cymbella maculata
Fragilaria pectinalis	Gomphonema pohliæforme
Diatoma flosculosum	Navicula hippocampus
Meloseira sulcata	Ceratoneis closterium
——— jurgensii	Coscinodiscus patina
Surirella?	——— lineatus
Synedra lævis	——— eccentricus
Cocconeis pediculus	Actinocyclus undulatus
Doryphora amphiceros	Actinoptychus senarius
Achnanthes longipes	Dictyocha gracilis

Ann. and Mag. N. Hist. sec. 2, i. 323.

* Forbes and Hanley, Brit. Mollusca, i. 7.

† Mem. xx. 14—"It would seem that the food of Ascidians consists of very minute particles of organised matter; for, although small crustacea and other animal remains have been occasionally met with in the branchial chamber, nothing of this nature has been observed in the stomach itself, and, as must be obvious to the reader, the oral aperture seems but little adapted to the deglutition of bulky substances."—Jones's *Anim. Kingd.* p. 372.

stant and quick vibration when the animal was left undisturbed. I presume them to be organs of a very delicate irritability, perhaps of taste;* and that their purpose is to hinder the ingress of noxious matters, not altogether mechanically, but because the sudden contraction of the oral aperture is a necessary sequence of their unpleasant irritations.† This aperture leads directly into the branchial sac, which, besides its office of a respiratory organ, seems to perform in part that also of a stomach; for that the process of digestion commences there, seems obvious from the fact, that numerous animalcules are generally found in it, but are never to be detected in the viscera of the abdomen. At the base of this sac there is another aperture (called by Cuvier the mouth), which conducts us, through the medium of a narrow membranous tube or œsophagus, into the proper stomach,—an organ always much smaller than the branchial sac, very variable in point of situation and form, generally puckered into longitudinal plaits internally, and sometimes studded with some glandular bodies; but its minute structure cannot be ascertained with any degree of accuracy. It contains, in general, only a little liquid;‡ while the intestinal canal, on the contrary, is almost, in every instance, filled throughout with a sufficiently consistent matter, sometimes grumous, more often homogeneous, of a yellowish grey colour, and rolled into little round or egg-shaped pellets, which it behoves us not to mistake for the proper ova. This canal is usually wide, and has a flexuous course; at first descending in the common sac, and then returning upon itself, it winds along the anterior side of the branchial sac, to open outwardly by a round aperture placed near the mouth, but distinguished by its lesser prominence. In the Alcyoneæ, it is otherwise like the mouth in form and structure; but, in Ascidiæ, there is no filamentous fringe at this orifice; which is furnished, instead, either with two valvular folds, or with a simple circular plait.

* "The disposition of the alimentary canal determines, in a manner perfectly absolute, the kind of food by which the animal is nourished; but if the animal did not possess, in its senses and organs of motion, the means of distinguishing the kinds of aliment suited to its nature, it is obvious it could not exist." Cuvier, *Comp. Anat.* i. 55. trans.

† "Il est garni d'une rangée de filamens charnus, ou de tentacules trés-fins, qui servent sans doute à l'animal pour l'avertir des objets nuisables qui pourroient se présenter et qu'il doit repousser." Cuvier, *Mém.* xx. 10.

‡ From this circumstance Savigny infers that the more gross and indigestible parts of the food are regurgitated, as they are in some nocturnal birds of prey. *Mém. sur les Animaux sans Vert.* ii. 8.

In many of the solitary Ascidiæ, the stomach is enveloped in a large liver,* which pours the bile directly into it through several orifices; and, in others, the parietes of the intestine are also thickened by a glandulous tissue, which probably secretes some liquor essential to proper digestion: but there is no liver in the social Alcyoneæ, or only some obscure traces of it in a few species, as in Diazona violacea; to the intestine of which, a little underneath the pylorus, are appended some little greenish tubes, simple, bifid, or trifid, which, Savigny conjectures, may be hepatic.† There is also an essential difference in the position of the viscera in the two families; the Ascidiæ have the abdominal viscera applied entirely against one of the sides of the branchial sac, beyond the base of which they do not project; on the contrary, the abdominal viscera of the Alcyoneæ are without and under the sac from which they are dependent, and often separated by a distinct pedicle, the terminal portion of the intestine being the only part which is connected with the thorax. There are, however, some intermediate species to show that this distinction is one of inconsiderable importance in their economy.

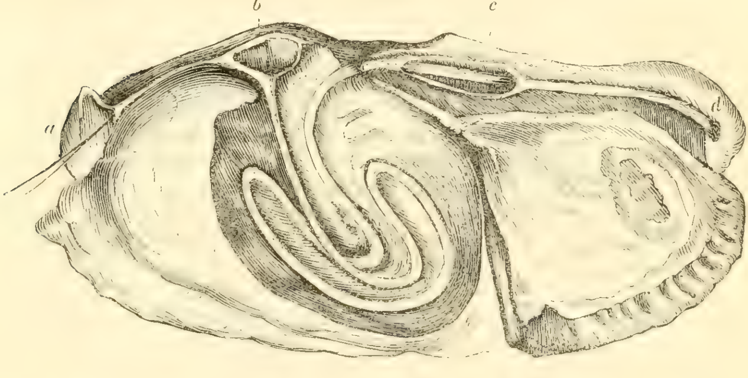
In the bivalved mollusks, the mouth, in the form of a transverse slit, is placed at the anterior part of the animal, deeply hidden between the foot and the anterior retractor muscle in the Dimyaria, and under a kind of cowl formed by the mantle in the Monomyaria. There is thus no necessity that in these animals, the nutritive fluid should pass over the branchiæ, but it is probable that the greater part really does so, for the current that enters by the respiratory siphon is driven forward and amid the gills, whence some part of it seems to be directed to the mouth, by the motions of the cilia, and by the movements of the *labial palps*, of which there are two on each side. These labial appendages are triangular in shape, and very variable in size; they are scored and ciliated, particularly on the inner surface, in the manner of the branchiæ, with which their connection is often very intimate; and they are almost always very soft, and directed backwards; but, in the Nucula, they are rigid, and pointed towards the mouth, similating a sort of jaws. There are no salivary glands, for, being destitute of any hard parts about the mouth for comminuting alimentary substances, glands for pouring in a fluid to blend with the food during that operation are not wanted. The œsophagus,

* In Boltenia there is no liver.—Savigny's *Mém.* ii. 88.
† Mem. ii. 37.

usually after a very short course, dilates into a stomach, the sides of which are perforated by the large hepatic ducts, coming from the liver, in the centre of which the stomach is imbedded. The intestine is very various in length; and its convolutions, interwoven with the liver and ovaries, are generally contained in great part in the foot. Having made its convolutions, the intestine is directed towards the heart, through the ventricle of which it commonly passes, and ends on the posterior muscle by an opening which, in some species, has a divided margin. This anus is situated between the lobes of the mantle, and opens into the tube which lies alongside and above the respiratory siphon. The liver has a follicular structure, and is distinguished among the other viscera by its green colour.*

To give you a clearer idea of the course of the alimentary canal in this class of animals, I will copy, on a reduced scale, Sir E. Home's figure of it taken from the freshwater mussel. In this figure (Fig. 54), *a* is the mouth, into which a bristle

Fig. 54.



has been introduced, *b* the stomach, after which you will observe that the intestine makes five turns in the foot amidst the ovary, and then, as rectum, runs posteriorly along the back of the animal beneath the hinge and above the respiratory organs, passing through the midst of the heart at *c*, and opening at *d* above the posterior muscle closing the shells, beneath the small tube of the cloak. This description applies generally to most bivalves, but in the oyster the rectum

* See Garner in Mag. Nat. Hist. n. s. iii. 164. Proc. Zool. Soc. iii. pt. i. p. 127. Zool. Trans. i. 272. Deshayes in Cyclop. Anat. and Phys. i. 696. Mery in Hist. de l'Acad. Roy. des Sc. 1710, p. 40.

does not pass through the heart; and in the Anomia the heart lies upon the intestine. In the Ungulina, Duvernoy finds that the gut passes not through the cavity, but through the parietes of the heart,—a fact which militates against the hypothesis that this curious penetration of the heart in these mollusks is to render easy a more immediate passage of the chyle into the circulating system. His own less probable conjecture is, that the contractions of the heart may aid the action of the intestines: "Il m'a semblé plus exact d'attribuer ce singulier rapprochement à la necessité d'exciter et d'aider les contractions de l'intestin pour la defécation." *

In this slight sketch I have purposely omitted to notice a very remarkable organ connected with digestion, and called the crystalline stylet. There is attached to or near the stomach a small process which Deshayes compares to the vermiform process of the cœcum in the higher animals. It is filled with this stylet,—an elastic, transparent, firmly gelatinous cylinder, rounded at one end and pointed at the other. The anterior extremity of this body is attached to the parietes of the stomach by means of small extremely thin and irregular auricular processes, while the other end projects into the stomach. The use of the organ is, perhaps, still conjectural. Lister, and the anatomists of his time, sometimes speak of it as analogous to the spine of vertebrated animals, and sometimes as connected with the reproductive function. Poli believed that it served to shut up the pores by which the bile is admitted, and so to regulate the flow of that secretion into the stomach. Blainville confessed his entire ignorance of its function; and Deshayes hesitates to suggest that it may act in bruising or comminuting the food. Mr. Garner asserts it to be "evidently analogous to the tongue of the Patella and other cephalous mollusca." Like the tongue, it is secreted from behind, and comes forward into the stomach; and the auricular processes or membrane is analogous to the membrane always found at the end of the tongue in other mollusca. Mr. Garner's opinion of its use, therefore, seems to be the same as Deshayes, but, he says, it has another use assigned to it,—"the giving elasticity to the foot, or, in the Anomia, where its extremity is seen in the mantle, the preserving in its situation the free extremity of the left lobe of the latter part." It may lessen the credit due from us to Mr. Garner's ingenious analogy, to remember that the stylet is not exclusively confined to these tongueless

* Ann. des Sc. Nat. (1842) xviii. 118.

mollusks, being found also in some Gasteropods, as, *e. g.* in certain species of Strombus, in Trochus turritus, and in a species of Murex.*

Our knowledge of the food of bivalves may be considered as almost entirely conjectural. It seems, however, to have been ascertained, that oysters feed upon infusory vegetables and animalcules; and, as it has been asserted, that while various species of these are beneficial, others are actually injurious, it seems to follow that oysters must be able to distinguish and reject the latter; and the organs of discrimination are undoubtedly the sensitive labial palps that guard the oral aperture. The green colour which oysters acquire in their parks of brackish water, is owing to the colour of the animalcules that furnish them their food; and hence M. Gaillon has remarked that other animalcules communicate to the oysters a colour similar to their own, tinting them or brown, or grey, or yellowish.†

Other bivalves are probably nourished by similar animalcules; for, when we reflect on their apparently helpless and inert condition, hampered with their shells, or even bound to the rock, we cannot but perceive that they are all unfit for the capture of any other prey than what floats about and within them. And how abundantly is this furnished! There are everywhere scattered on the bed of the wide ocean extensive beds of oysters, clams, mussels, &c., containing millions of individuals, which are hourly devouring, each of them, crowds of animalcules (embracing in the term the infusory, microscopic, crustaceous and gelatinous medusæ), which, from their vast numbers and rapid reproduction, never fail them. At some seasons of the year I have seen the waters of our shores literally in a move with Entomostraca; and I am fully satisfied that, when Scoresby calculated a cubical mile to contain 23,888,000,000,000,000, he was not exaggerating the actual fact.‡ In one family of

* Edinb. New Phil. Journ. vii. 231.

† Edinb. New Phil. Journ. iv. 196.—The excrement of oysters has given rise to a curious simile; "And though some count a jesting lie to be like the dirt of oysters, which (they say) never stains, yet is it a sin in earnest."—Fuller's *Holy and Profane State*, p. 379.

‡ "The number of Medusæ in the olive-green sea was found to be immense. They were about one fourth of an inch asunder. In this proportion, a cubic inch of water must contain 64; a cubic foot, 110,592; a cubic fathom, 23,887,872; and a cubical mile about 23,888,000,000,000,000! From soundings made in the situation where these animals were found, it is probable the sea is upwards of a mile in depth; but whether these substances occupy the whole depth is uncertain. Provided, however, the depth to which they extend be but 250 fathoms, the above immense number of one species may occur in a space of two miles square. It may

bivalves furnished with a byssus, we frequently find entangled amid its fibres, or concealed within the valves, one or more small crabs (Pinnoteres), of which the older naturalists, who never left an observation to stand, like truth, all naked, but ever clothed it with some pretty vestment, tell us a tale not to be passed over in this place, and which I present you in the words of Dr. Philemon Holland, the laborious translator of Pliny. "The Nacre, also called Pinnæ, is of the kind of shell fishes. It is alwaies found and caught in muddie places, but never without a companion, which they cal Pinnoter, or Pinnophylax. And it is no other but a little shrimpe, or, in some places, the smallest crab, which beareth the Nacre companie, and waites vpon him for to get some victuals. The nature of the Nacre is to gape wide, and sheweth vnto the little fishes her seelie body, without any eie at all. They come leaping by & by close vnto her; and seeing they haue good leaue, grow so hardie & bold, as to skip into her shel and fill it ful. The shrimp lying in spiall, seeing this good time & opportunitie, giueth token thereof to the Nacre, secretly with a little pinch. She hath no sooner this signall, but she shuts her mouth, & whatsoever was within, crushes & kills it presently; and then she deuides the bootie with the little crab or shrimp, her sentinell and companion. I maruell therefore so much the more at them who are of opinion, that fishes and beasts in the water haue no sense."*

Of bivalves there are some which, as I have told you, bore into wood and rocks; but I need scarcely guard you against entertaining the supposition that they eat the material on which they work, although there are authors who have attributed to them "a stone-eating power and appetite." The Teredines, however, really eat the wood destroyed by them; for Mr. Hatchett proved the pulp in

give a better conception of the amount of Medusæ in this extent, if we calculate the length of time that would be requisite, with a certain number of persons, for counting this number. Allowing that one person could count 1,000,000 in seven days, which is barely possible, it would have required that 80,000 persons should have started at the creation of the world, to complete the enumeration at the present time! — What a stupendous idea this fact gives of the immensity of creation, and of the bounty of Divine Providence, in furnishing such a profusion of life in a region so remote from the habitations of men! But if the number of animals in a space of two miles square be so great, what must be the amount requisite for the discoloration of the sea, through an extent of perhaps 20,000 or 30,000 square miles!"—SCORESBY's *Arctic Regions*, i. 179. — See also Darwin's Journal, iii. 14, &c.

* Hist. of the World, i. 261.

their intestine to be vegetable sawdust; but I agree with Sir E. Home in thinking (as Sellius, indeed, long before asserted), that the sawdust serves only as a substance in which the real food procured from the sea is entangled and prevented from escaping too readily from the stomach.† I will give you Sir Everard's description of the digestive organs of these animals, which a comparison will prove to be altogether different from those of the more typical bivalved mollusca.‡ The œsophagus (Fig. 55, *a*) is now very short, and lies on the left side of the neck: the canal swells out, and becomes stomach (*b*), which, in its external appearance, is a large bag, extending the whole length of the cavity of the abdomen, but when laid open it is found to have a septum (*c*) dividing it longitudinally into two equal portions, except at the lowest part, where they communicate (*d*), the septum being wanting. The intestine has its origin close to the termination of the œsophagus, is extremely small, dilates into a cavity containing a hard white spherical body the size of a pin's head, and then makes a turn upon itself. The course it follows is shown by the letters *e* in the cut.‡

Fig. 55.*

* This figure represents the course of the stomach and intestines of Teredo navalis, removed from the body. *a*, The œsophagus; *b*, the stomach; *c*, the septum, dividing it into two cavities; *d*, the aperture by which the two cavities of the stomach communicate; *e*, the course of the intestine to its termination.—*Comp. Anat.* t. 80.

† See Hancock in Ann. and Mag. N. Hist. ser. 2. ii. 232.

‡ Home's Comp. Anat. i. 373.

LETTER XVIII.

THE CARNIVOROUS MOLLUSCA.

Although it may be true, as stated in the preceding letter, that the great proportion of the Conchifera subsist on infusorial entities, or on food in a state of molecular division, yet there can be no doubt that some of the larger and locomotive species seek a more substantial fare, and feed on worms or other animal matter in a state of partial decay; which they seem to have the power of grasping by means of their extensible labial appendages. Thus the large Cyprina islandica and the Modiola vulgaris of our seas often swallow the bait of the fisherman; and in the stomach of an individual of the former I once found the undigested remains of a large green Nereis enveloped in a pulp too consistent certainly to have been the sediment from water, however loaded with molecules.

In their manner of feeding, these Conchifera resemble the pectinibranchial Gasteropods whose shells have a notch or canal at the base of their apertures; and it is important you should remember that it is only, with a few exceptions, the Gasteropods of this order (Pectinibranchia) so circumstanced that are truly carnivorous. They embrace the cowries, the cones, the volutes, the rock shells and the whelks, all of which live on animal food; and it seems to be indifferent to them whether their prey is dead, or still fresh and alive; but, in the latter case, it is obvious, if you remember the inactivity, and sluggishness, and total want of cunning of these molluscs, that the prey they can master must be fettered and stationary, or endowed with locomotive powers and arms not superior to their own. It is not unlikely that they may prefer a dead prey to a living one, for we know that the whelks will take a bait readily; in search of which they frequently enter the baskets laid for crabs and lobsters, which are always baited with garbage; while in tropical climes we are told that men fish for the olives with lines, to which small nooses, each containing a piece of the arms of a cuttlefish, are appended.

You could never have anticipated that the Bivalved Mollusca (Conchifera) would be found among the prey of these

carnivorous tribes, than which there are apparently no animals less fitted to gain access to their strong-holds, so that even Blainville has expressed himself incredulous on the point.* But the fact is certain, and has been known since the time of Aristotle;† nor, indeed, is it hastily to be believed that such an improbable statement would have been made by the Stagyrite, had it not rested on his personal observation. The Purpuræ prove extensively destructive to mussels and other littoral bivalves: the Buccina feed upon those which burrow in sand in somewhat deeper water; and it is very probable, considering the similarity of their organisation, that all the whelks and rock-shells, and perhaps all the pectinibranchial zoophagous Gasteropods, have the same taste, and an equal capacity of gratifying it. How, you ask, and by what means? Do they glide insidiously, and pop a stone between the valves, to prevent their closure? or do they venture slily to insinuate their foot, and seize upon the unwary inmate? The first they cannot do, and the latter I should deem a hazardous attempt; but nevertheless it is affirmed that the Buccinum undatum really runs the hazard in its attacks upon the Clam (Pecten opercularis), to which it bears a great enmity.‡ This is not, however, their usual method, which is—what you might never guess—by boring a hole in one valve, through which they reach their miserable victim. On examining a number of valves of dead shells, of Mactræ and Anatinæ especially, you will perceive in many, and generally near the beaks, a small circular hole drilled with a neatness that the gimlet of the artisan could not more than emulate; and these holes are the workman-

* As Rondeletius did before him. He maintains that the Purpuræ can only draw out and suck the snails. *Hist. des Poiss.* ii. 45.

† Hist. Anim. lib. iv. cap. iv. sec. 148—9.

‡ "Is commonly taken in dredging by fishermen, who either use the animal for bait, or destroy it, from a supposition that it is very destructive to the Large Scollop, Pecten maximus, by insinuating its tail (as it is termed) into the shell, and destroying the inhabitant: this, we have been assured, they will do even in a pail of sea-water." Mont. *Test. Brit.* p. 238. The mode in which they anciently fished for the Purpuræ proves the danger. "Now these purples are taken with small nets, and thinne wrought, cast into the deep; within which, for a bait to bite at, there must be certain winckles and cockles, that will shut and open, and be ready to snap, such as we see those limpens be, called mituli. Halfe dead they should be first, that, being new put into the sea again, and desirous to revive and live, they might gape for water: and then the purples make at them with their pointed tongues, which they thrust out to annoy them; but the other, feeling themselves pricked therewith, presently shut their shells together, and bite hard. Thus the purples, for their greedinesse, are caught and taken up, hanging by their tongues." Holland's *Plin.* i. 259.

ship of the Gasteropods in question. Fixing the shell of their prey by the disc of the foot, they apply against the point where they mean to penetrate, the apex of the proboscis; and now, by a constant rubbing or grating of their filiform, rough, spinous tongue, assisted, as some affirm, by the softening action of some solvent, they succeed, after much pains, in perforating through the valve.* Reaumur, who investigated the subject with great care, was the first to suggest that the process was not entirely mechanical. He found, in the first place, that the hole was not invariably of the same form, as it should have been had it been worked out by an instrument which does not vary in its make, but some of the holes were round and some oval; 2ndly, the bottom of the hole is as wide as its entrance, a kind of bore which a pointed instrument could not effect; and 3rdly, he detected in the bottom of some unfinished holes a stronger water, which he concluded to be of a solvent quality. This solvent, Cuvier thinks, is furnished by the anterior salivary glands, which open forwards into the proboscis;† and this opinion is more probable than that of Dr. Bancroft, who conjectures that it may be the same as the purple secretion. This fluid, as I formerly told you, when exposed to the light gives out an odour nearly resembling that of garlic. "This odour, to my senses," says Dr. Bancroft, "unequivocally indicates the presence of phosphorus, which is contained in all animal substances; and, when subjected to the action of the sun's rays, readily becomes volatile in part by combining with a portion of oxygen; and this volatile part or compound (which, as Davy observes, should, according to the principles of the French nomenclature, be called phosphorous acid) emits an offensive alliaceous smell, very much like that of the colouring matter of the Buccinum, when it becomes purple. The last, or that part of it which gives the smell of garlic, readily mixes with water, and strongly impregnates it with this odour, as I have found by many experiments; and in this respect it also agrees exactly with the volatile compound which gives the alliaceous odour from phosphorus."‡

* "The purple hath a tongue of a finger long, pointed in the end so sharpe, and hard withall, that it is able to bore an hole and pierce into other shell-fishes, and thereby shee feeds and gets her living." HOLLAND's *Plin.* i. 258. The ancients were better informed on this subject than some modern writers, who have attributed these operations to the Trochus. See Smellie's Phil. of Nat. Hist. i. 396.

† Mem. xv. 9.

‡ On Colours, i. 155.

But the proboscis (Fig. 56), the organ by which this work is effected, demands a more detailed description; for its mechanism is scarcely less wonderful than the analogous organ of the elephant. It is cylindrical, and of considerable length, and when not in use is kept retracted within the body, where it lies beyond the reach of injury. The better to understand its structure, we may represent it as being formed of two flexible cylinders, one within the other, and which are united at the upper margin, so that, in drawing out the interior cylinder, we can only lengthen it at the expense of the other; and, on pushing it back again, we, in shortening it, give corresponding extension to the exterior, but the latter lengthens only on the upper side, because it is fixed to the parietes of the head by its inferior margin. Let us now add a number of longitudinal muscles, all of them very much divided at both extremities: the stripes of their internal or superior extremity are attached to the parietes of the body, those of the opposite end all along to the internal surface of the inner cylinder of the proboscis; and their action, consequently, is to draw this cylinder and the whole proboscis inwards. When thus retracted, a great part of the internal surface of the interior cylinder makes part of the external surface of the exterior cylinder, and it is just the contrary when the proboscis is elongated and protruded. The protrusion of the inner cylinder by the unrolling of the exterior, or, which is the same thing, the evolution of the proboscis, is effected by its own peculiar annular muscles: these encircle it all its length, and, by contracting in regular succession, they force it out beyond the lips, in a manner perfectly similar to the evolution of the tentacula of the snail. There is, in particular, one muscle, near the place where the exterior muscle is attached to the head, which is stronger and more effective in this operation than all the others. When extended, the proboscis can be bent to all sides, and at any point, by the action of the retractor muscles, parcels of them acting, while others assume the place and office of antagonists. The Figs. 57, 58, and 59 will serve to illustrate this interesting mechanism. In Fig. 57, the proboscis is retracted about a half: the external cylinder (*a*) is seen enveloping a portion of the inner (*b*), the end of which (*c*) is the end of the proboscis: the muscles which draw it within the body (*d d*) are in a state of contraction, and at *e* we see the great annular

Fig. 56.

muscle, the use of which is to push forwards the inner cylinder, and consequently lengthen the organ. In Fig. 58, this muscle, and all the annular fibres, have by their action greatly protruded the proboscis, and its retractor muscles

Fig. 58.

Fig. 57.

Fig. 59.

(*d d*) are extended and laid bare; the exterior cylinder (*a*) has become very short, and the interior (*b*) is proportionably lengthened. Fig. 59 represents the two cylinders cut up in a longitudinal direction to show what they contain, and in what manner the retractor muscles are distributed upon the inner parietes. In the inner cylinder we find the tongue, with all its apparatus (*e e*), the salivary canals (*f f*), and the greater portion of the gullet (*g g*): the tongue is a very narrow cartilaginous membrane, armed with numerous acute spines or prickles curved backwards; and the principal purpose of the elongation of the proboscis is seemingly to carry its rough point to the body which the snail wishes to perforate and suck.*

And this "rough point" is sufficient of itself to do the work without the concurrence of any hypothetical solvent,

* Cuv. Mem. xvii. 7.

as Da Costa suspected,* and as Mr. Albany Hancock has proved by his discovery of the composition of its prickles, which are truly sharp siliceous teeth. "I found," he says; "this apparatus in Buccinum undatum to be composed of rows of stout, much-curved spines or teeth, of great brilliancy, and as glossy and transparent as glass, and certainly to have no appearance whatever of horny tissue. They are so similar to those of Eolis, that there could be little doubt that they are formed of the same material; and accordingly, after subjecting them to the action of acid, such was found to be the case. Their capacity to drill holes in calcareous matter, is therefore easily understood, without the necessity of supposing the aid of a solvent requisite, as surmised by Cuvier."†

This anatomy of the proboscis is derived from an examination of the organ in Buccinum undatum, but it is applicable to all the pectinibranchial or proboscidian Carnivora. The other organs subservient to digestion in this tribe present nothing remarkable in their organisation. The stomach is a membranous bag, irregularly plaited on the inner surface; the intestinal canal, like that of carnivorous animals in general, is short; and the lower portion, or the rectum, the inner coat of which is raised into several strong longitudinal folds, is wide, and opens on the right side of the branchial cavity under the margin of the collar. Cuvier observes that the sides of the rectum are thickened by a whitish substance, fatty, and a little granular, of which the use is unknown.

The Naticæ,—fine shells which live near the lowest ebb of the tide, or within it, burrowing in the sand, or in sand-banks far from shore,—are all carnivorous, and also borers of other shells. Dr. Gould‡ asserts that they are very voracious, and play a conspicuous part in devouring the dead fish and other animals which are thrown up by the tide. The small circular holes with which bivalve shells are often drilled, are the work of these snails, and made by them to gain an entrance to the animal apparently so well secured against such a foe. The foot can be expanded so

* "And, if the holes, which are most commonly found in some species of the Chamæ, and the Screw Shells particularly, are examined with a glass, they will be found to be so finely circular, that it is impossible to conceive any menstruum should act upon it in so regular a manner."—*Elem. of Conchology*, 216.

† Ann. and Mag. N. Hist. xv. 113.—The Purpura lapillus pierces the common mussel in the same way, and by a similar instrument.—*Ann. and Mag. N. Hist.* ser. 2, ii. 247.

‡ Rep. Inverteb. Anim. Massachussetts, 232.

as to envelope completely the objects on which they prey, for a long retention of it in its grasp is necessary from the slowness with which they work their auger or spiniferous tongue.

It appears to be ascertained that the Bullæ are also feeders on the Bivalved Mollusca. Mr. Humphreys mentions that he had found a species of Mya alive in the gizzard of Bulla lignaria.* Cuvier says that the stomach of the Bullæ, in general, is usually filled with the remains of small shells :† and Mr. Sowerby tells us that they are "exceedingly voracious, as is evident from the fact, that the animal of B. aperta is sometimes distorted by having swallowed entire a Corbula nucleus, which is a very thick and strong shell, nearly equal in size to itself."‡ Now as the Bullæ have no perforating instrument in the mouth, nor jaws to crack them, they are under the necessity of swallowing their prey entire, and, as might have been anticipated, there is provided an internal apparatus to supply the deficiency of the oral armature, and break up the shells, so that the inmates may be exposed to the influence of the digestive agents. This singular apparatus is placed within the gizzard, and consists of three strong calcareous pieces, differing in form and size in the different species, thus modified, undoubtedly, to suit them to their peculiar wants, and moved by powerful muscles against each other.§ In the Aplysia, a genus of the same natural order (Tectibranches) as the Bulla, we find a curious modification of this structure, accompanied, however, with a total discrepancy in the tastes and propensities of the creature ; and this is a fact which deserves to be remembered in estimating the value of inferences, in relation to the habits of animals, drawn from their presumed affinities. The oral organs of Bulla and Aplysia are nearly the same, and there is a resemblance in their complicated digestive apparatus ; but instead of three shells, the muscular gizzard of the latter is studded with numerous sharp pyramidal knobs of a semi-cartilaginous consistence, and of unequal sizes, and which may be rubbed off very easily, for they have no muscles to attach and move

* Lin. Trans. ii. 16. † Mem. x. 14.

‡ Gen. Rec. and Foss. Shells, No. 39.

§ Cuv. Mem. x. 13. These stomachal teeth (first noticed by Apuleus) were described by Gioeni, a Knight of Malta, and professor of Natural History at Catania, as a new genus of multivalve shells ; a genus retained by Retzius, Bruguière, and Lamarck, until the fraud was detected by Draparnaud. See Bosc, Vers. i. 76 ; and Babbage on the Decline of Science, p. 175. Spalanzani has given a very interesting notice of the Chevalier Gioeni's Museum in his travels in the Two Sicilies, i. 310, &c.

them.* When Bohadsch saw this structure for the first time it seemed to him so anomalous and wonderful, that numerous dissections were required to convince him of its being the natural armature of the organ, and he fell into the erroneous conclusion that it was fitted to triturate the shells on which the animal was presumed to prey. † But the Aplysia is really herbivorous, as is asserted by Pessonel, Cuvier, and others ; ‡ and, were it necessary, I could add my testimony to this fact, having at one time kept a large specimen of Aplysia mustelina for nearly three months in a state of confinement, during which it was fed on fuci only, and these it ate greedily, showing some partiality to the Dulse (Fucus palmatus). The food, previously to its reception in this curious gizzard, has passed through a large membranous crop, in which it probably undergoes little change : in the gizzard it is broken down, and in this state enters a third stomach, armed also on its internal surface with hook-like prickles directed forwards, and intended, doubtless, to tease the fibrous mass, that it may be more thoroughly subjected to the dissolving virtue of the gastric juices, and reduced to a homogeneous pulp previously to its commixture with the bile, which flows into this viscus from two large orifices close to the pylorus, opening between two small membranous prominent crests. §

Among the other families of Gasteropods, I do not remember any that are exclusively carnivorous, except the genus Testacellus, to outward appearance scarcely differing from the common slug, but distinguished by carrying a small shell above the tail; and a species of Vitrina, or shelled terrestrial snail, found under stones in moist, shady, or grassy situations in the higher parts of the Island of Madeira. Unlike the slugs, the Testacellus burrows in the soil, and is the dread of the earthworm on which it feeds ; and these habits are accompanied with corresponding changes in its organisation. Its body is more cylindrical than that of the

* Pessonel's description of this organ is short, but characteristic :—" The membranes are thick, and are set with twelve stones, or horny pieces, of a bright yellow colour, and as transparent as fine yellow amber, ending in points like a diamond ; so that the great side, or basis, is set into the membrane of the gizzard, as a diamond in its socket. Others differ in size, having different figures, that, in acting all together, they may be able to break and grind the herbs the animal feeds upon, as well by the strength of the muscle, or gizzard, which puts them into action, as by the situation of these stones, assisted by grains of sand found in it, turning the whole by this trituration into a liquor." *Phil. Trans.* vol. 50 , 1758, p. 587.

† De Anim. Mar., p. 19 and 22.

‡ Darwin's Journal, iii. 6.

§ Cuv. Mollusq. Mem. ix. 18.

slug, and, in lieu of a shield confined to a limited portion of the neck, the whole body is encased with a thick coriaceous coat, to guard from the additional pressure to which it is exposed, and to afford sufficient strength to execute its furrows. But the most marked differences are found in the digestive organs. In the mouth there is no corneous denticulated jaw, nor a membranous spinigerous tongue; but from between two vertical lips issues a very small cylindrical proboscis, and appropriated to it a muscle which forms the most curious part in the structure of the creature. It is large, cylindrical, lies along the whole belly, and is attached to the left side of the back by a dozen of very distinct fleshy slips, almost perpendicular to the principal muscle of the body.* The size and strength of this muscle indicate its paramount importance; and its actions are of a twofold nature. When the Testacellus has become aware of the presence of a prey, to surprise and take it unawares is necessary, for the earthworm when alarmed is more alert by far than its foe. The advantage is given to the latter by having the power, through the medium of this muscle, of suddenly darting out the proboscis, which in an instant is projected and applied to the object in view. It is then retracted by the same muscular apparatus, and made simultaneously to grasp with firmness the struggling victims of its ferocity. Mr. G. B. Sowerby, in reference to Testacellus scutulum, says he was surprised "that an animal generally so extremely sluggish in its motions, after discovering its prey by means of its tentacula, thrusting from its large mouth its white, crenulated, revolute tongue, should instantly seize upon, with extraordinary rapidity, and firmly retain, an earthworm of much greater size and apparent force than itself; but which, by its utmost exertion, is unable to escape." To increase its power of retaining a secure hold, the tongue is furnished, around and just beneath (if not upon) its margin, on the outside, with short hair-like bristles.†

The carnivorous Vitrina (Helicolimax lamarckii of Ferussac) differs from our native species in some respects; but, according to the Rev. Mr. Lowe, to whom we owe our acquaintance with its habits, "is so closely allied, that it would be very rash at present to separate it" from the genus.‡ When leaves and other vegetable matters were

* Cuv. Mem. xii. 7. † Mag. Nat. Hist. vii. 227 and 414.

‡ This opinion of Mr. Lowe's is confirmed by the anatomy of the species, excellently developed by the Rev. M. J. Berkeley, Zool. Journ. No. xix. p. 305.

given to it, they were never touched, even although care was taken that the Vitrina should have nothing else for nearly a fortnight; but, on the very first night of its confinement, it would kill and eat a small snail, and it preyed on its own species greedily, the larger slaying the smaller, and then indulging its cannibal appetite. Two of nearly equal size being put together, the stronger or braver slew his neighbour, which furnished a plentiful repast for two or three succeeding nights, for it is during this season only that they feed.* It would be well to ascertain whether our own Vitrinæ are not equally carnivorous and addicted to cannibalism: they are at present believed to be herbivorous; but Mr. Jeffreys informs us that V. pellucida "has the same carnivorous propensities as the smaller Limacidæ and Testacelli; and I once," he adds, "detected no less than seven individuals busily engaged in feeding on a scarcely dead earthworm, which was faintly writhing about, and endeavouring in vain to get rid of its assailants."†

The Pteropod Mollusca are undoubtedly zoophagous; the minute Crustacea and Medusæ, or particles of dead animal matter floating in the sea, furnishing their nutriment Some species of this order abound amazingly in the Arctic Ocean, where the marine vegetation seems too scanty for the requisite supply of food; and, moreover, they are found floating far from the shore, and at the surface, where no vegetables are. We have, however, no certain information on this head.

On the contrary, it is well ascertained that all the Cephalopoda are carnivorous, and for voraciousness and ferocity may justly claim precedence among mollusks. Such of them as swim in the bosom of the ocean, as Loligo, feed upon fish in general, and they will frequently tear large pieces from those which have swallowed the baited hook, and deprive the fisherman of his gain. I have had more than one specimen of Loligo vulgaris brought me, which, adhering with a fatal tenacity to the fish, had allowed itself to be drawn from the water; and in the stomachs of others I have found not only the undigested remains of this food, but the beaks of small individuals of their own species.‡ The tribes, again (Octo-

* Lowe in Zool. Journ. iv. 342. † Linn. Trans. xvi. 506.

‡ The fact of their feeding on their own kind was known to Ælian, who thus speaks of the Polypus in the first chapter of his Miscellanies:—"They have terrible stomachs, and nothing can save itself from being devoured by them. They frequently attack one another, when the smaller one, being caught and involved in the tresses of the more powerful, becomes a meal for it."

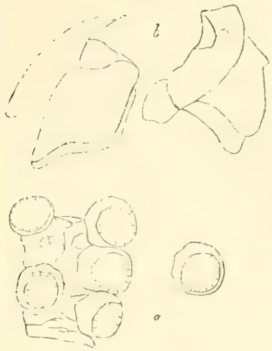
podeæ and Nautili,)* whose habit is to crawl along the bottom, and seek concealment in rocky places, prey principally on the larger Crustacea, which find in their hard spiny shells, and their powerful claws, no protection against these voracious enemies. In the Mediterranean, the Octopi are held in detestation by the fishermen, because of the havoc they commit among the most esteemed species of lobsters and crabs, which is so extensive that scarcely any are to be found in their usual haunts during the summer season, and what have chanced to escape evince, by their mutilated condition, the peril they have run.† According to the early naturalists, the cuttle entraps its prey, partly, at least, by stratagem: "And albeit otherwise it be a very brutish and senselesse creature, so foolish withall, that it will swim and come to a man's hand; yet it seems after a sort to be witty and wise, keeping of house and maintaining a familie: for all that they can take they carry home to their nest. When they have eaten the meat of the fishes, they throw the empty shels out of dores, and lie as it were in ambuscado behind, to watch and catch fishes that swimme thither."‡ Pliny also informs us, on the authority of Trebius Niger, that the Cephalopoda "Are most desirous and greedie of cockles, muscles, and such like shell fishes;" and in order to reach the animal scatheless, they "lie in wait to spie when the said cockles, &c., gape wide open, and put in a little stone between the shels, but yet beside the flesh and bodie of the fish, for feare lest, if it touched and felt it, she would cast it forth again: thus they theeve, and without all danger, and in securitie get out the fleshie substance of the meat to devoure it: the poor cockles draw their shels together for to clasp them between (as is above said), but all in vaine, for by reason of a wedge between, they will not meet close, nor come neere together. See how subtle and craftie in this point these creatures be, which otherwise are most sottish and senseless."§

The cuttlefish, I need scarcely remark, are all guiltless of this clever stratagem: their warfare, though cruel, is open, and they are amply furnished with the necessary weapons. The long flexible arms which encircle the head are set along their inner aspects, with numerous cup-like suckers, which the animal can fix to any object, and the adhesion is strengthened by a horny ring round the edge of each sucker often pointed with sharp curved teeth. (Fig. 60. *a.*)

* Owen's Mem. on the Pearly Nautilus, 24. † Cuvier, Mem. i. 4.
‡ Holland's Pliny, i. 250. § Holland's Pliny, i. 251.

"When an animal of this kind approaches any body with its suckers, in order to apply them more intimately, it presents them in a flat or plain state; and when the suckers are thus fixed by the harmony of surfaces, the animal contracts the sphincter, and forms a cavity in the centre, which becomes a vacuum. By this contrivance, the sucker adheres to the surface with a force proportioned to its area, and the weight of the column of air and water, of which it constitutes the base. This force, multiplied by the number of suckers, gives that by which all or a part of the feet adhere to any body. This power of adhesion is such, that it is easier to tear off the feet than to separate them from the substance to which the animal chooses to attach itself."* It must, then, be a fearful thing, for any living creature, to come within their compass, or within their leap, for captured by a sudden spring of several feet, made "with the rapidity of lightning," and entangled in the slimy serpentine grasp of eight or ten arms, and held by the pressure of some hundreds of exhausted cups, escape is hopeless, and the struggles of the hapless victim, by bringing its body into more rapid contact with the suckers not yet applied, only accelerate its fate.

Fig. 60.



The jaws, and a portion of the enlarged part of the foot, of Loligo sagittata.

As a sort of illustration I may remind you of the following fishing custom of the natives of the South Sea Islands:—"They have a curious contrivance for taking several kinds of ray and cuttle-fish, which resort to the holes of the coral rocks, and protrude their arms or feet for the bait, but remain themselves firm within the retreat. The instrument employed consists of a straight piece of hard wood, a foot long, round, and polished, and not half-an-inch in diameter. Near one end of this, a number of the most beautiful pieces of the cowrie or tiger-shell are fastened one over another, like the scales of a fish or the plates of a piece of armour, until it is about the size of a turkey's egg, and resembles the cowrie. It is suspended in an horizontal position by a strong line, and lowered by the fisherman from a small canoe,

* Cuvier, Comp. Anat. Trans. i. 432. See also Roget, Bridgew. Treat. i. 260.

until it nearly reaches the bottom. The fisherman then gently jerks the line, causing the shell to move as if inhabited by a fish." "The cuttle-fish, attracted, it is supposed, by the appearance of the cowrie (for no bait is used) darts out one of its arms or rays, which it winds round the shell and fastens among the openings between the plates. The fisherman continues jerking the line, and the fish puts out arm or ray till it has quite fastened itself to the shells, when it is drawn up into the canoe, and secured." *

This resolved fixedness of the cuttles on their prey is a trait of their disposition that had been early noticed. You may remember that Homer makes mention of it, when he wishes to impress upon us the firmness of Ulysses' grasp on an occasion of imminent danger :—

> "As when the Polypus, enforced, forsakes
> His rough recess, in his contracted claws,†
> He gripes the pebbles still to which he clung.
> So he Ulysses within his lacerated grasp
> The crumbled stone retain'd, when from his hold
> The huge wave forc'd him, and he sank again."

Ovid, likewise, describing how the nymph Salmacis detained Hermaphroditus in her embraces, compares her to a serpent twining round the head and wings of an eagle, to ivy encircling an oak, and, finally, to the Polypus holding fast his adversary :—

> "Utque sub æquoribus deprensum polypus hostem
> Continet, ex omni demissis parte flagellis."‡

And Plautus (in the "Aulularia"), in reference to rapacious flatterers, exclaims : — "Ego istos novi polypos, qui sibi quicquid tetigerint tenent." The knowledge of the fact,

* Ellis, Polynes. Researches, i. 144.

† The friend to whom I am indebted for these classical notices, tells me that the word here translated *claws*, is *κοτυληδοναι*, which properly signifies the cups or sucking disks with which the arms are studded.—The passage in Southey's edition of Cowper's Odyssey, is considerably different from that we have given, and the description of the Polypus is not less erroneous :—

> "———————— but yet again
> The refluent flood rush'd on him, and with force
> Resistless dashed him far into the sea.
> As pebbles to the hollow polypus
> Extracted from his stony bed, adhere,
> So he, the rough rocks clasping, stripped his hands
> Raw, and the billows now whelm'd him again."
>
> Book v. l. 517-23.

‡ Metam. iv. 366.

and the study of the apparatus by which the hold is given, has suggested to the ingenious Professor Simpson (a name now very dear to humanity) an instrument that may do away with the use of others often hurtful in unskilled hands and difficult of application. To substitute a safe power for the accoucheur's forceps was the professor's worthy object, and he writes me, — "After great battling and baffling, I looked at last at the form of nature's suckers in the cuttle-fish. I found they were double cups, and, in imitating this, I immediately got a small caoutchouc sucker made, capable of pulling thirty or forty pounds, which is far more than is required by the forceps in nineteen cases out of twenty." *

There are two tribes of cotyligerous or dibranchiate Cephalopods,—the octopods and decapods. † The prehensile organs of the former are, as the name indicates, eight in number, all of the same kind, developed from the muscular cone enclosing the apparatus of the mouth, and in general very long proportionably to their short rounded bodies. Their suckers are arranged in one or two rows along the oral aspect, diminishing in size by insensible gradations until they become almost invisible at the tapered gracile extremities ; and there are numerous similar suckers scattered over the membrane that covers the mandibles. The limb of these suckers is flat and soft, but marked with striæ or furrows which radiate from their hollow centre, and may oppose an obstacle to their gliding over a slimy surface. The decapod cuttles have eight analogous arms or feet, but they are always greatly shorter, — a fact which is the more remarkable since the body in this tribe is usually lengthened and pointed below ; and you might not unreasonably imagine that as they are swimmers, roaming at large in the wide ocean, and living on agile prey, a great length of arms was the more necessary to them. 'Tis very true ; and to remedy this seeming defect, there has been given two long additional tentacula, nearly similar in structure to the arms but more pliant, and, like them, armed with cups either along their whole line, or more commonly only at

* See also Monthly Journ. Med. Science for Feb. 1849.

† I here employ, as throughout the work, the usual nomenclature of conchologists, but strictly speaking, "all the naked Cephalopods are *octopods*, the disk which produces these feet by its division, never producing a greater number than eight ; but in many genera, two retractile pedunculated tentacula are developed, and extend from within this outer subdivided disk, and generally between the first and second anterior arms on each side, which has given rise to the division termed Decapoda in this class. The tentacula, however, never assume the form of the other feet."—GRANT *in Trans. Zool. Soc.* i. 21.

their extremities, which are enlarged and dilated to afford them a firmer and broader seat. These tentacula, except in one or two instances, "arise from the cephalic cartilage, close together, internal to the origins of the ventral pair of brachia; they proceed at first outwards to a large membranous cavity situated anterior to the eyes, and thence emerge between the third and fourth arms on either side." Their cups or suckers are also encircled with a horny spinous ring; and these spines are sometimes so much developed as to deserve the appellation of claws,—a structure which, you at once perceive, must greatly increase their powers of retention. With these formidable tentacula, extended in front to the full, the prey is caught, and firmly grasped; and now by their being shortened and coiled up in the infraorbital cavities whence they emerged, it is brought within the reach of the shorter arms, whose function is to retain it against the mouth until it is devoured.

I cannot enter into any detail of the variations which these organs — the arms and tentacula — undergo in the different genera, but among them there are two so very surprising as necessarily to challenge some notice. In the Onychoteuthis — the most formidable of Cephalopods—there are at the extremities of the long tentacula, besides the uncinated acetabula or cups, a cluster of small, simple, unarmed suckers at the base of the expanded part. "When these latter suckers are applied to one another, the tentacles are firmly locked together at that part, and the united strength of both the elongated peduncles can be applied to drag towards the mouth any resisting object which has been grappled by the terminal hooks. There is no mechanical contrivance which surpasses this structure: art has remotely imitated it in the fabrication of the obstetrical forceps, in which either blade can be used separately, or, by the interlocking of a temporary joint, be made to act in combination."*—The final cause of my other example is not so obvious, for the economy of the animal appears to be unknown. Take up your pencil and draw for me a decapod cuttle-fish. Let the form be like that of a Loligo, the body of small size, but give whatever length to the tentacula you may deem fair and reasonable for a body of more than twice its bulk. There is an unlicence certainly in the drawing, but nature has surpassed your fanciful portrait. The Loligopsis veranii does not exceed four inches in length, — the

* Owen in Cyclop. Anat. and Phys. i. 529. To this article of Mr. Owen's, I would wish to refer the student for the fullest and most accurate history of the Cephalopoda.

tentacula are two feet and a half, and as slender as a thread! The like is not to be found exampled among organized creatures, for these tentacula have no analogy with the filaments of annulose animals; and the filaments which dangle from the Physalia and certain Medusæ possess none of their organic importance, and are neither fitted for, nor applied to, similar purposes. In the Loligopsis the tentacula are garnished all along the stalk with minute sessile suckers, which, as usual, become larger on the clavate extremities. How these slender organs are moved, how their motions are propagated along the lengthened line,—how the club at the end of such a flexible line is supported,—and how the organs are preserved from amputation or injury, are all questions which start upon us as we contemplate the creature, and to which it is not easy to give a satisfactory answer; for you must further know that these elongated tentacula cannot be retracted and hidden in a cephalic cavity as I have told you can be done with those of the Loligo and Sepia, there being no such cavity in this anomalous species. To account for the movements of the organs, it may be conjectured that the longitudinal muscular fibres in their composition are susceptible of partial contractions in any point of their course as the animal may will; and if we further suppose that every cup along their stalk is a centre of attachment to these fibres towards which they may contract, we get, in fact, a series of short independent muscles, under whose play the tentacula may be stretched out or inflected, or spreada broad or brought into nigh contact, and fixed to and around any prey that may be floating careless at a distance, and unconscious of danger from such a foe!*

"The animals which we have thus seen to be endowed with so various and formidable means for seizing and overcoming the struggles of a living prey are provided with adequate weapons for completing its destruction, and preparing it for deglutition." The digestive system of the class, however, is less uniform in structure than, from the sameness of their food, we might at first suppose; but, in sketches of the very general character to which I limit myself, I pass over the peculiarities of tribes, to notice little beyond what is common to the class. The mouth, formed by a puckered fold of the skin, is placed at the base, and in the centre of the circle formed by the feet, and is armed with two powerful corneous jaws, having a vertical motion: they are fashioned to the

* Ferussac in Ann. des Sc. Nat. n. s. iii. 341-3.

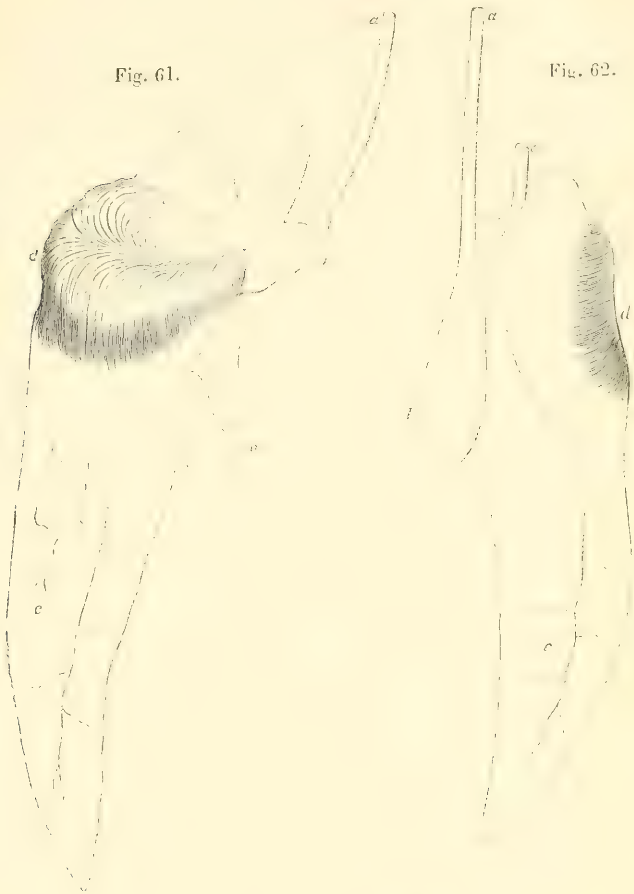
resemblance of a parrot's bill (Fig. 60, *b*), and are well adapted to tear their prey piece-meal, or crush the hard shell, especially when, as in the Nautili, their tips are hardened and calcareous.* Between the jaws lies the tongue, adherent to the platform of the mouth, but capable of being unrolled to a slight extent, and having its surface roughened with many rows of small sharply-pointed tricuspidate, or semi-tricuspidate teeth, set in close and regular array, which can be erected at will, so as in some measure to grate down the food, previously to its transmission to the gizzard, and they greatly facilitate its descent by their direction, and by their motion backwards and forwards. In the mouth, the food is mixed with the saliva, which is secreted by one or two pairs of large glands.† The gullet is a narrow membranous tube, of nearly uniform calibre throughout in the Loligo (Figs. 61, 62, *a*), and penetrating the substance of the liver before it enters the stomach; but, in the Octopus, the gullet is only bound to the surface of the liver, and at the point of attachment swells out into a large membranous crop, of the appearance of which, in the Octopus ventricosus at least, I cannot give you a better idea than by comparing it, both in size and position, to the bulb of a small retort. The stomach (Figs. 61, 62, *b*) is a thick muscular organ, like the gizzard of a fowl, and strongly corrugated internally in a longitudinal direction: immediately beyond it, in the Sepia and Octopodiæ, and also in certain Teuthidæ, is situated a curious spiral appendage, or rudimental pancreas, laminated on the interior, into which the bile is poured; but in the Loligo vulgaris, instead of this spiral cœcum, and, as it were, to compensate for its deficiency of a crop, there is a very large membranous and somewhat cylindrical bag (Fig. 61, 62, *c*), on the posterior and upper part of which we trace vestiges of the spiral structure, for there a fatty substance is so disposed as to assume that form, having the outer edges cut in a deeply serrated manner (Fig. 61, 62, *d*). I have found this bag always filled with a grumous fluid, and it is undoubtedly the organ in which digestion is completed; for it not only receives the bile, but is itself, or the spiral part of it, supposed to furnish a secretion analogous to that of the pancreas in higher animals. The aperture between the gizzard and this cœcum is oblique and valvular, and another adjoining aperture leads

* Owen, Mem. on the P. Nautilus, p. 21.

† In Nautilus, these glands are wanting, but the tongue is more completely developed than in the other Cephalopods.—Owen, *lib. cit.* p. 23.

to the intestine (Fig. 61, 62,* *e*), which like the œsophagus, winds upwards along the surface of the liver to terminate in

Fig. 61. Fig. 62.



The stomach of Loligo vulgaris.

the funnel, which is the common vent of all the excrements. The liver is very large in all the genera of this class, and must furnish a copious supply; but, besides this, and the

* In reference to these figures, it may be observed that they are copied from nature; a remark which seems necessary, since they differ entirely from Sir E. Home's figure of the stomach of Loligo vulgaris, or the Sepia Loligo of Linnæus. Sir Everard's figure appears to have been taken from a species of Octopus.

secretions of the other accessary organs to good digestion, Sir E. Home believes that the inky fluid is intended also to have some effect upon the lower portion of the intestinal canal, to enable this to extract from its contents "a secondary kind of nourishment," * — an opinion not very probable in itself, and with but a few fanciful analogies in its support.

* Comp. Anat. i. 369 and 393.

*** Troschel and, more particularly, M. Löven, have sought in the form and various armature of the tongue of the Cephalophorous mollusca (viz., Cephalopoda, Pteropoda, and Gasteropoda), a character on which to distinguish their natural alliances and affinities. The researches of Löven into this subject seem to have been extensive, and are very interesting; but I am only acquainted with them through the medium of an imperfect translation, with the perusal of which I was favoured by Mr. Alder of Newcastle. Hence, I cannot presume to offer the results, at which Löven has arrived, to the student.

LETTER XIX.

THE PHYTIVOROUS MOLLUSCA.

The herbivorous, or, as they are frequently named, the phytophagous mollusca, belong exclusively to the class of Gasteropods, and embrace, with few exceptions, the Pulmones, about half of the Nudibranches, the Inferobranches, a great proportion of the Tectibranches, the Scutibranches, and Cyclobranches, and such of the Pectinibranches as have no slit or siphon in the collar of the mantle, or, which is the same thing, whose shell has an entire aperture.* The mouth of the animal is not elongated into a proboscis, but is furnished with two jaws; and the tongue is usually broad and membranous, although sometimes long and filiform. What proportion these herbivorous tribes united may bear to the zoophagous, I am not prepared to say, for we are not in possession of a complete catalogue of the species; but to make a conjectural approximation to the solution of this question, let us assume that the enumeration of the species given by Lamarck is equally defective in all the families, (and I know of no fairer mode of coming at the truth,) when we shall find that the phytivorous are fewer by a third than the zoophagous, — so that Meckel errs in asserting that the great bulk of the Gasteropods live on vegetable matters:—

ZOOPHAGOUS.		PHYTOPHAGOUS.	
Nudibranches	13	Tritoniens	13
Bulleens	13	Laplysiens	5
Testacellus	1	Phyllidiens	56
Ianthina	2	Semi-phyllidiens	3
Naticæ	12	Calyptraciens	42
Canaliferes	274	Limaciens	8
Ailees	42	Colimaces	268
Purpuriferes	197	Lymneens	28
Scalariens	11	Melaniens	22
Columellaires	172	Peristomiens	21
Enroulees	328	Neritacees	80
Heteropodes	8	Macrostomes	26
		Plicaces	11
	1073	Turbinecees	163
			746

* That is to say, the families Trochoides and Capuloides of Cuvier, Règ.

The marine tribes live on sea-weed,—

> ——— "part single, or with mate,
> Graze the sea-weed their pastures, and through groves
> Of coral stray;"

and it is probable that the species in general are not limited to any particular weed, nor are even very nice in their selection. At the same time it may be observed, that some are rarely found except on one and the same plant, as, for example, the pretty Patella pellucida, which pastures almost uniformly on the broad frond of Laminaria digitata, and has shown both sense and taste in choosing so wide and tender a field. Still more provident in its way, is another common species of Patella, or, perhaps, a variety only of that just mentioned, which is usually found occupying a cavity or cell in the root of the same sea-weed. Insinuating itself amid, or under the entangled root, it eats into its very core until a cavity is made sufficiently large, where it may find a full repast ever at hand, and at the same time a snug residence, secure from almost any foe, and sheltered from every ordinary storm. I have often admired the apparent sagacity of the creature in its choice, and amid the bustle of life, have sometimes envied its quiet seclusion, which is not so strict as to exclude all society, for I have frequently seen two Patellæ dwelling together in the same "peaceful hermitage."

The land tribes seem to refuse no tender herb: we know that they will eat with avidity the spring corn, clover, peas, and turnips; they are very fond of all kinds of fruit; and the mushrooms afford the slugs a grateful delicacy, even the poisonous, acrid, and milky species being greedily devoured by them.* To me, they seem to prefer all these in a fresh state; my personal observation leads certainly to this conclusion, though I am aware it has been said that they, like

Anim. iii. 72 and 86.—Adanson had given the distinguishing characters between the zoophagous and phytophagous pectinibranchial mollusca very correctly.—Hist. Nat. du Senegal, p. 80, 81, 193. The Phytophaga are "eminently distinguished from the carnivorous race by two characters; their mouth does not form a proboscis: and the aperture of their shell is entire,—in other words, without the notch or canal for the passage of the siphon."—Swainson's *Malacology*, p. 56 and 158.

* See Ann. Nat. Hist. ix. 73. It is stated somewhere in the Gardener's Magazine, that Helix aspersa has been seen to feed on the fiery-flavoured foliage of the Clematis flammula! Of a very acrid agaric described by Lister he says, "I observed these mushrooms even then, when they abounded with milk (not to be endured upon our tongues), to be exceeding full of fly-maggots; and the youngest and tenderest of them were very much eaten by the small, gray, naked snail."—*Corresp. of Ray*, p. 100.

modern epicures, are fonder of their food when it has advanced some way to putrefaction. Dr. Fleming says:—"Those which are phytivorous, appear to prefer living vegetables, and refuse to eat those which are dried. We are not aware that putrid vegetable matter is consumed by them, although many of the snails and slugs are found under putrid leaves and decayed wood. In those places there is shelter from the sun, together with dampness; so that it is difficult to determine whether they sojourn in an agreeable dwelling or a well-stored larder."* On occasions they eat voraciously; but, when necessary, they can sustain a fast longer, perhaps, than any other animated beings; snails having been kept for upwards of a year, nay for years, and the Limnäeæ and Planorbes for many months, without any food, except that small and tenuous portion which they might extract from the air or water.

The mouth in this tribe, as in other mollusca, is always anterior and terminal, with often an inferior aspect; in Doris, and Cyclostoma, and a few others, it is prolonged into a sort of snout, which can be shortened or elongated to a small extent; in Aplysia and Pleurobranchus, there are labial tentacula at the sides; and it is overshadowed in the Tritonia by a deeply crenate veil, which receives a very remarkable developement in the Tethys, of which I have already given you a figure. It is in no instance furnished with the complicated retractile proboscis of the pectinibranchial Zoophaga; but, on the contrary, we very generally find, within the lips, jaws of a cartilaginous or horny texture,† fitted for dividing their food into appropriate portions. In the marine tribes there is a pair of these instruments acting horizontally; but they differ so much in size, form, and even consistence, in the different genera, that no general description could be made applicable. Usually they are merely oblong pieces of cartilage; sometimes thin reticulated plates: whereas, in Tritonia, they are composed of solid horn; and, in reference to their form, Cuvier compares them to the scissors with which sheep are shorn, the blades being large, oblong, curved, deeply emarginate behind, and partially serrulated on the upper edge, (Fig. 63, 6). The slugs and snails (Pulmonifera), whether terrestrial or aquatic, have a single jaw‡ placed on the upper side of the oral aperture; and it acts in cutting the herbage by being

* Edinb. Encyclop. xiv. 602.

† Doris, Pleurobranchus, and the pectinibranchial Phytophaga (Littorina, Trochus, Nerita, &c.) in general are exceptions.

‡ Hook, in his *Micrographia*, has given a magnified view and description

brought to press against a mammillary eminence on the floor of the mouth ; it is of a semilunar shape, hard and corneous, and either serrated on the cutting edge, or armed with a single obtuse knob in the centre. The tongue is a membrane roughened with minute prickles, set in the most regular array, either in close transverse lines, or on the angles of a network of the most minute delicacy. These prickles, by pointing backwards, prevent any regurgitation of the food ; and, as they are capable of being raised and depressed at pleasure, they must tear and rasp the vegetable fibre into shreds, and prepare it for an easier digestion. The shape of the tongue, and the pattern in which the prickles are set, are very variable ; and I know few objects which are more interesting to the microscopical observer. It is always, as Swammerdam remarked of that of Paludina vivipara, "so elegantly formed, that it can scarce be exactly described, and as difficultly be represented in a figure ;"* for, indeed, the figures which have been given of it convey not the slightest idea of the extreme beauty and delicate organisation of this wonderful organ ; nor am I able to supply this deficiency. It is sometimes broader than long, as in Tritonia and Doris ; at other times elliptical or spoon-shaped, as in the snails ; and in others it is lengthened out in the most extraordinary manner, so as not merely to equal, but greatly to exceed the length of the body ! † In the latter cases it lies reversed along the gullet, and reaches the interior of the stomach, where it is convoluted or twisted into spiral bendings, like a serpent closely rolled together. The Periwinkles (Littorina) and Limpets afford familiar examples of this remarkable modification ; and I enclose a figure of it

of the snail's tooth, p. 180. tab. 25, fig. 1. See also Swammerdam, Book of Nature, p. 49 ; Lister, Exer. Anat. de Cochleis, tab. 2, fig. 2, and tab. 3, fig. 9 ; List., Conch. Anat. tab. 1, fig. iv., and tab. 4, fig. ii. ; Cuvier, Mem. pl. ii. fig. 4.

* Book of Nature, p. 79. Cuvier asserts that the tongue of the slugs and snails is not spinous, and that the food is introduced into the gullet by a sort of peristaltic movement of the tongue and the buccal mass on which it lies.—*Mem.* xi. 17. Swammerdam says, "On the tip of the tongue of the snail, there is a little horny bone, cut as it were, into two or three very tender little teeth ; with which, as with a hook, the snail, when it is about to eat, first lays hold of the small herb, and immediately after, suddenly snatches and pulls the piece into its mouth ; afterwards it nips them pretty fast with its teeth, so that the noise it makes in biting and eating may be sometimes heard very distinctly." p. 49.

† For a rude and unfinished figure of the tongue of Tritonia, see Cuvier's Mem. tab. 2, fig. 8, 9 ; of Aplysia, tab. 2, fig. 6 b ; of Paludina, tab. 1, fig. 8, 9 ; of Patella, tab. 2, fig. 18, 19.—The figures of the tongue of the Nudibranches, given by Alder and Hancock in their Monograph, are the best of any hitherto published.

(Fig. 63, 5, *a*), from the Common Limpet: it is a narrow riband-like body, fully three inches long, of nearly equal breadth throughout, except at the apex, where it is soft and some-

Fig. 63.

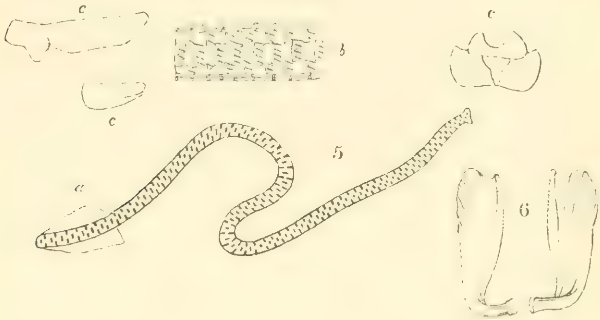


Fig. 63, 5, *a*, the tongue, natural size, of the Common Limpet (Patella vulgata); *b*, a portion magnified; *c*, *c*, *c*, the cartilaginous jaws.—Fig. 6, jaws of Tritonia.

what dilated, the surface roughened with three rows of teeth, the side rows alternating with the middle one, which is quadrifid, while the side teeth are divided only into two points. This curious spinigerous tongue is never protruded beyond the margin of the lips. It seems to be used for rasping down the food; and, in proportion as the anterior prickles are worn away in this operation and absorbed, another portion of the tongue is brought forward to supply its place; but, that there may be no deficiency in its length, we find the apex soft and vascular, where, in fact, a continual growth and addition are going on.*

When a phytophagous Gasteropod is about to eat, it thrusts forward, and to a certain extent evolves, the spinous tongue, protruding at the same time the lip on each side, by which the tongue is compressed and forced into the form of the bowl of a spoon. The food is now taken hold on by the lips, drawn forwards and retained by the prickly tongue, and simultaneously pressed against the upper horny jaw, by which means a portion is bitten off, sometimes with a very audible noise. The detached morsel is then passed along the tongue, torn and rasped down by its sharp prickles, and, forced on by the peristaltic motion of the organ, and by the retropulsive action of the adjacent muscles, the mass is made to enter the gullet. At the entrance of this canal there is an uvular caruncle, which is probably the seat of

* Cuv. Mem. sur la Patelle, p. 18.

the animal's taste; and on its sides a pair of lobulated salivary glands, or sometimes two pairs, which have each a single excretory duct to convey their peculiar secretion into its upper part, to lubricate and soften the mass. The gullet is a muscular canal, lined interiorly with a mucous coat, presenting, indeed, the same structure as the whole alimentary canal, and is generally plaited in a longitudinal direction. But the variety exhibited in the form, structure, and disposition of the stomach and intestines is too great to permit us to attempt a general view. The former is sometimes merely a membranous bag, or simple dilatation; sometimes there is a gizzard, analogous to the gizzard of birds,* to triturate the food previously to its transmission into this bag; sometimes there is a series of dilatations, or stomachs, three or four; and, again, in others we find the gizzard, or stomach, armed with horny teeth, or laminæ, of which the Scyllæa affords a remarkable instance.† "There is no division of the alimentary canal into small and large intestines, as in the higher classes; or rather, among the mollusca, the relative size of the different parts is reversed. Here the pyloric extremity is usually the largest, while the anal is more slender."‡ The intestine is usually a simple canal, which, after making a volution or two among the lobes of the liver, returns upon itself, and opens outwardly on the side towards the anterior part of the body; but, in Doris, the anus is pierced on the back towards the tail; and we find, in Chiton and Dentalium, other exceptions to the usual course; for, in them, the intestine is straight, and has a posterior terminal aperture, like the annulose tribes. To show to what extent the alimentary canal is varied in this tribe, let me give you a representation of that of the Tethys (Fig. 64), which you will compare with that of Pleurobranchus (Fig. 65 §); and, again, contrast these with the same parts in Patella (Fig. 66). That these contrasts in structure are ac-

* Of the stomach of Limneus Swammerdam, says, "It is of the same structure, in all respects, with that of the hen or cock kind; so that one would think the real stomach of a hen is here represented, without any difference, but that it is much smaller."

† Cuv. Mem. 10, tab. 1, fig. 6.

‡ Fleming Phil. Zool. ii. 411.

§ "In the Pleurobranchus, the œsophagus dilates into a membranous crop (fig. 65, *a*), at the lower part of which (*b*) the bile is poured in. It communicates by a narrow cardia with the second stomach (*c*), which is a gizzard with thin but muscular parietes. The third stomach (*d*) is membranous, and precisely resembles the plicated stomach of ruminants, in being disposed in large but delicate folds, by means of which the alimentary matter contained in it is moulded into long whitish cords. The fourth stomach (*e*) is membranous, like the crop, but smaller. It is remarkable

companied with decided peculiarities in the quality of food, can scarcely be doubted; but we know nothing of what

Fig. 64. Fig. 65. Fig. 66.

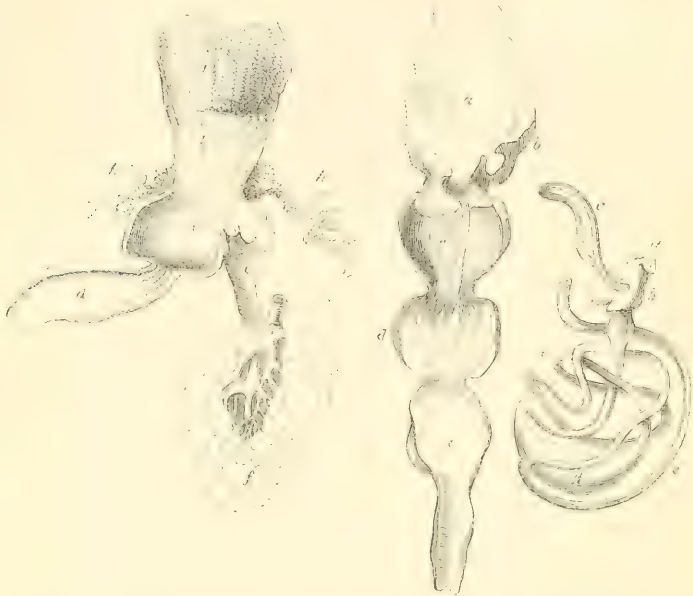


Fig. 64. Alimentary canal of the Tethys: *a*, the proboscis; *b*, the œsophagus; *c*, the stomach; *d*, the intestine; *e*, hepatic duct; *f*, the liver; *g*, hepatic artery; *h*, *h*, salivary glands: the parts are laid open.—Fig. 65. Alimentary canal of the Pleurobranchus: *a*, first stomach; *c*, second stomach; *d*, third stomach; *e*, fourth stomach.—Fig. 66. Alimentary canal of the Patella: *a*, the mouth; *b*, the buccal mass; *c*, the tongue; *d*, the stomach; *e*, *e*, the intestine.

these peculiarities are: their manner of feeding, and, we may even add, their kind of food, are almost conjectural. Blainville gives it as his opinion, that all the species destitute of jaws must swallow soft and decayed vegetable and animal matter: being, by their structure, incapacitated from chewing a fresh material.* But the conclusion is a hasty one; for I, at least, am not inclined to attach that value to deductions of this kind which many seem to think they merit. The Aplysia has very small obtuse mandibles, of a soft cartilaginous substance; yet that mollusck eats its sea-

that the gizzard contains a narrow groove running through its whole length, leading from the first to the fourth stomach, and probably subservient to a species of rumination."—Carus, *Comp. Anat.* trans. ii. 10.

* Man. de Malacol., p. 177.

weed bit by bit, and nips away a portion from a large frond as easily as the Tritonia can be supposed to do. It is not unlikely, however, that those jawless species which possess the spinous tongue may take their food by rasping it off the surface by aid of the prickles; for it may be remarked that the Patellæ and the periwinkles, when active, are constantly protruding the anterior portion of the tongue between the lips, and withdrawing it in rapid succession.

The liver appears to be proportionally greater in these tribes, in relation to the other viscera, than in the zoophagous mollusca; and, unlike that of the acephalous mollusca, it rarely envelopes the stomach. It occupies, very generally, a backward position among the viscera, filling the upper convolutions of the shell; and it is composed of lobes and lobules,* of which the ultimate are in the form of hollow globules, in each of which a biliary vessel originates. These vessels, by successive reunions, contribute to form one, three, or four large canals, which open directly into the stomach, and pour in, we may presume, a large quantity of bile; essential, apparently, to the rapid digestion and assimilation of the food. Sometimes the biliary pores, as in Doris, are so large, that Cuvier wonders by what means the food is prevented entering them;† but, according to Professor Grant, it actually does enter and fill them. "Upon opening the cavity of the stomach," says this distinguished naturalist, "we see, as in the tunicated animals, and in the inhabitants of bivalve shells, the large perforations leading from the cavity into the substance of the liver. Here, again, we observe the short, wide hepatic ducts, bearing the same general character which they have from the lowest of the mollusca up to the class of fishes. Baron Cuvier remarks, that it is surprising the vegetable food does not gain admission from the stomach into the cavities and substance of the liver. I have collected many of those animals upon our coasts, and have opened them in all conditions as regards food taken into their stomach, and I have found the stomach often completely filled with minutely divided portions of coarse marine plants; but I never found them with their stomach thus filled, without finding that the hepatic ducts were also filled with the food. These

* Swammerdam says it is divided into lobes, "according to the different course of the intestines, which make as many divisions in it as they have turnings and windings." Our description of the liver is derived from Blainville, Man. de Malacologie, p. 123. See also Lambron's description of the liver of Helix pomatia in Edin. Med. Surg. Journ., vol. liv. p. 505.

† Mem. sur le Doris, p. 15.

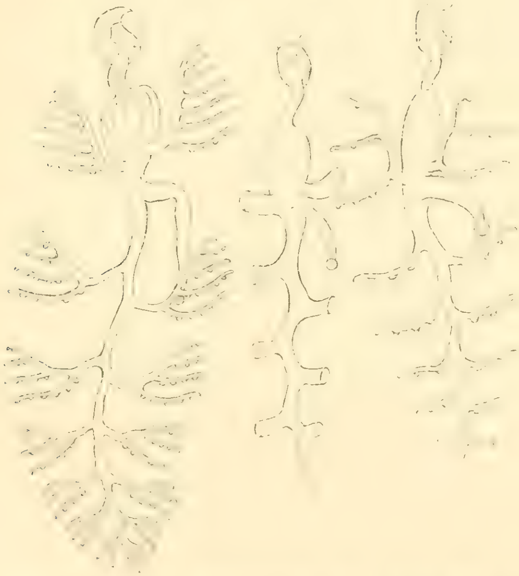
hepatic ducts are obviously continuations developed from the stomach itself, and the obliquity of their entrance does not protect them from the ingress of the food. We observe opening, also, into the stomach of the Doris, which is destitute of teeth, a glandular cœcum of a pyriform shape. That glandular cœcum differs obviously in its structure and form from the structure of the liver. It consists of a single wide cavity, studded internally with minute glandular orifices or follicles: it opens into the pyloric extremity of the stomach, and, consequently, pours its secretion into the alimentary canal at the same place with the liver. From this position of the organ, and this termination of its duct, we cannot consider it as analogous to the salivary glands. From its position in the vicinity of the hepatic organ, it is rather analogous to the *pancreas* in higher animals. This I was more anxious to examine, on account of its having been stated by Cuvier and by many other writers, that no invertebrated animals possess a pancreas. Tiedemann has adopted my view of this gland; Meckel, in his last work, was inclined to do the same; but Cuvier continued to regard it as a peculiar organ. This form of the pancreas exists also in the Aplysia and some other Gasteropods; and I have also shown that, under a more complicated form, that organ exists in the Cephalopods."*

It has often been remarked that the liver of the mollusca is proportionably more voluminous than in other animals, and of a looser texture.† In many of them it is deeply lobulated,—so much so in the genus Onchidium that it seems to have three livers,—and in some Tritoniæ it is broken up into branched lobes, which are prolonged into the branchial plumes garnishing the sides of the body. And this approach towards disintegration reaches its acme in the Eolidæ, where the biliary furnisher becomes a mere lining to a set of vessels connected with the alimentary canal, and to which Milne-Edwards has applied the term "gastro-vascular." The name was intended to indicate to us that in these vessels there was a combination of the functions of the digestive and circulating organs—organs of chylification as well as of assimilation; and although doubts may exist relative to their fitness for this double duty, yet the name may be retained as pointing out the vascular-like character of these intestinal appendages.

* The Lancet, No. 572, p. 708-9; and Edin. Phil. Journ. xiii. p. 198.
† Lister Exer. Anat. de Coch. terr. p. 79, 80.

The system is found fully developed only in the Eolidæ. In these delicate and beautiful Nudibranches the short œsophagus leads into a comparatively large pear-shaped stomach; and from the upper surface of its posterior extremity a short intestine proceeds, which, after a slightly tortuous course, terminates anteriorly, on the right side of the body, in a small nipple-like vent. But, besides this intestine, another chylous vessel is continued from the stomach, in the form of a wide tapering canal, along the median line, and terminates near the posterior extremity of the body in a blind sac. From the stomach itself, as well as from its continuation, branches are given off in pairs, not, however, in perfect symmetrical order, but always more or less alternating. These branches give off smaller tubes, which are continued into the branchial papillæ, and lined with a follicular apparatus for the biliary secretion. The enclosed figures (Fig. 67), copied from the engravings of

Fig. 67.



Messrs. Hancock and Embleton, will give you a correct idea of what I have attempted too shortly to describe;*

* On the Anatomy of Eolis, in Ann. and Mag. N. Hist. xv. p. i., and 77. See also Ann. and Mag. N. Hist. xii. 236; and Allman on the Anatomy of Actæon, in vol. xvi. 146.

but you must remember that the dendritic character of the system is not always so much exaggerated, if I may use the expression. It varies, in fact, considerably in the different genera, passing through some intermediate steps to its full developement, and again receding to normal simplicity in other genera, as in Limapontia and Chalides, in whom there are only two large pouches for the retention and elaboration of the alimentary matters.*

Now, you must beware of believing in the existence of any unbroken barrier between the mollusca that feed on herbage and the mollusca that feed on flesh. That certain families are herbaceous and others carnivorous, under ordinary circumstances, is very true; but in every order or class you will find some genera or species that break the rule, and indulge in a diet repulsive to the class as a body. Perhaps no mollusks are so pre-eminently carnivorous as the Cephalopods, but I know that some of them do feed occasionally,—not on olives, as Pliny tells us,† but on sea-weed, for I have found the stomach of Loligo sagittata crammed full of fragments of the midrib of Alaria esculenta, and pieces of the same were sticking between the mandibles, as if the creature had been killed in the act of eating. The Scalaria, Turritella, Velutina, Ianthina, and Stylifer, genera which the characters of their shells would decide to be herbivorous, are really and exclusively carnivorous. The favourite food of the Ianthina appears to be the gelatinous Velella, whence, it is said, that it derives the blue tincture of its shell; and the Stilifer lives a parasite amid the forest of spines that clothes the Echinus, or burrows under the skin of the star-fish, upon whose juices there is reason to believe that it feeds. "With that instinct of self-preservation imparted to all parasites whose existence depends upon that of their nidus, the Stilifer, like the Ichneumon among insects, appears to avoid the vital parts; for in no instance did Mr. Cuming find it imbedded anywhere save in the rays, though some had penetrated at their base and very near the pelvis."‡

Of the Nudibranches, which are usually, and, with regard to many of them, properly classified with phytivorous mollusks, the greater number appear to be animal feeders.

* Ann. des Sc. Nat. (1844) i. 16. Also the vol. for 1845, p. 275.

† Of the Octopodus, Rondeletius says,—"Ils mangent les coquilles de mer, ils aiment fort les branches de l'olivier, et par cette friandise on les prend, ils aiment aussi le figuier."—*Hist. des Pois.* i. 373.

‡ Broderip in Proc. Zool. Soc. ii. 60.

This must of necessity be the case with those which swim in the open sea, and with those which live amidst the plant-like corallines and florulent zoophytes, embracing the majority of the Tritoniadæ and Eolidæ; for, at the depths in which these animated productions are found, no sea-weeds can grow.* Thus Mr. Bennet tells us that the Glaucus feeds greedily on the gelatinous Porpitæ and Velellæ;† and in the fleshy gizzard of the toothless and tongueless Tethys, Cuvier found fragments of shells, and the legs and other remains of little crabs.‡ I took what appeared to be the fry (Fig. 68) of Asterias papposa from the stomach of a Tritonia; and Sir John Graham Dalyell assures us that the appropriate food of Tritonia hombergii is the Lobularia digitata, a common and nauseous zoophyte.§ Messrs. Alder and Hancock have seen the Eolis punctata devour other Nudibranches, and make a repast of its own spawn; and Eolis coronata, with equal carnivorous propensities, does not hesitate to feed on its own species, the weaker falling

Fig. 68.

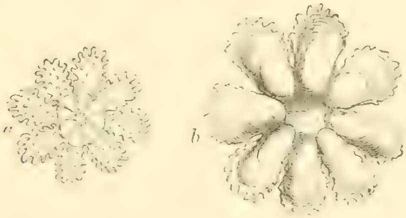


Fig. 68, *a*, the upper, *b*, the under surface.

a sacrifice to the cravings of the stronger. "Large individuals will content themselves with plucking off each other's papillæ; but, should a smaller specimen be within reach, it is most mercilessly attacked, the more powerful animal laying hold of any part of the weaker that may happen to be nearest. The tail, however, is generally first seized, and fierce and determined is the onset. The de-

* Many testaceous Gasteropods, which we conclude to be herbivorous from the character of the shell, live at depths where sea-weeds are very rare or awanting. These species may be presumed to live on corallines. "Now that the observations of M. Decaisne, M. Kutzing and others have so clearly proved the vegetable nature of that singular production (the Nullipore), so long regarded as a zoophyte, the source of the food of the holostomatous testacea in these deep regions is no longer problematical."—E. Forbes *in Reports Brit. Assoc.* 1843, p. 165.

† Proc. Zool. Soc. 1836, iv. 116 and 119.

‡ Mem. p. 12.

§ Rare and Rem. Anim. Scot. ii. 180.

vourer raises and shakes his papillæ in the manner that the porcupine shakes its quills when irritated, and then, laying back the dorsal tentacles, and curling up the oral ones, fixes the protruded mouth and jaws upon his prey, when, with a convulsive shrinking up of the body, morsel after morsel is appropriated. In this manner it is not uncommon to see an individual entirely devour another, half its own size. We have also seen this species feed upon a Lucernaria."*

So also the pulmonated Gasteropods have a strange hankering after flesh, and become very cannibals in satisfying this propensity. Lister asserts that snails will eat not only bread and cheese, but flesh of all kinds, particularly fish and salted meat;† and, in another place, he tells us that, having once placed an individual of the Helix aspersa with another of the Arion ater in a vessel together, he found, on the following day, that the former had slain the slug, and had miserably torn and eaten its skin, "tantus animus est etiam pigerrimis animalibus."‡ I have repeatedly seen the Black Slug (Arion ater) feeding on individuals of its own species which had been accidentally crushed, and were yet scarcely dead; and the observations of Mr. Power, which have been since confirmed, show that they feed voluntarily on earthworms, dead or dying. Of the aquatic tribes, we are informed by Mr. Jeffreys, that "the food of the Limnei is animal and vegetable matter in different states of putridity; which makes them deserve the perhaps not unapt epithet of 'scavengers of the waters.' In the absence of other nourishment, they will even devour each other, piercing the shell near its apex, and eating away the upper folds of its inhabitant. This accounts for the mutilated and often imperfectly repaired state of the upper volutions of some specimens."§

Relative to the times when molluscous animals feed, a very few facts only have been ascertained. Among the earlier naturalists it seems to have been a prevalent belief, that oysters and other bivalves were fat and in season at the full moon, and lean and out of season at the new moon.|| A. Gellius tells a story pat to the purpose:—"The poet Annianus, on his Falerian estate, was wont to spend the time of vintage in a jovial and agreeable way; and he had invited

* Brit. Nudibranch. Mollusca, pt. ii. pl. 12 and 15.

† Exer. Anat. de Coch. 90. See also Mag. Nat. Hist. viii. 80.

‡ Anim. Ang. p. 114.

§ Lin. Trans. xvi. 371.

|| "Ostreis et conchyliis omnibus contingit, ut cum luna pariter crescant, pariterque decrescant."—Cicero, *De Div.* ii. 14.

me and several other friends to pass those days with him. When we were at supper there, a large quantity of oysters was brought from Rome; but when they were set before us, they proved, though many, yet all poor and thin. The moon (remarked Annianus) is now in truth waning; and on that account the oyster, like other things, is lean and void of juice. We asked what other things waste when the moon is old? Do not you remember (said he) what Lucilius says?—

> 'Luna alit ostrea, et implet echinos, maribu' fibras
> Et pecui addit.'

Those very things which grow with the moon's increase pine away as it wanes: the eyes of cats also become fuller or smaller according to the changes of the moon. But that is still more surprising which I have read in Plutarch,—that the onion becomes green and flourishing as the moon wastes away, and dries up again while the moon increases: and this is the cause, say the Egyptian priests, why the Pelusians do not eat the onion; because it alone of all pot-herbs has its turns of diminishing and increasing contrary to those of the moon."* This opinion continued to be for long a part of the popular creed, and even so late as 1666 it had in nothing been impaired, for, in the "Philosophical Transactions" of that year, travellers to India are solicited to inquire, "whether those shell-fishes that are *in these parts* plump and in season at the full moon, and lean and out of season at the new, are found to have contrary constitutions in the East Indies:"—a nice question, to which the answer returned was, "I find it so here, by experience at Batavia, in oysters and crabs."† To the marine zoophaga there are probably no set hours or seasons, and I do not see why it

* Kirckringius "knew a young gentlewoman whose beauty depended upon the lunar force; insomuch, that at full moon she was plump and handsome, but in the decrease of the planet so wan and ill-favoured, that she was ashamed to go abroad, till the return of the new moon gradually gave fulness to her face, and attraction to her charms. If this seems strange, it is indeed no more than an influence of the same kind with that which the moon has always been observed to have upon shellfish, and some other living creatures; for, as the old Latin poet Lucilius says,

> 'Luna alit ostrea, et implet echinos, maribu' fibras
> Et pecui addit.'

And after him, Manilius:—

> 'Si submersa fretis, concharum et carcere clausa,
> Ad lunæ motum variant animalia corpus.'"—Dr. Mead.

† Sprat's Hist. R. Soc. p. 161.

should be otherwise with the Phytophaga, although the latter certainly inhabit a shallower water, and may consequently be somewhat influenced by the degree of light. The littoral species appear to feed during the night, as Mr. Guilding informs us the Chitonidæ do on the shores of the Caribbean Sea.* Many Nudibranches are only active when the night has lent them its genial shade, and perhaps lured their prey to a fatal sleep. Snails and slugs in general prefer to dine, like ourselves, late in the evening, when the sun's fervour has abated, and the dew has begun to fall; but, most unlike ourselves, they may be found at breakfast, their appetites not a whit blunted by their late prandial repast, in the very early mornings of summer, before the sun even has risen to drink up the evening's moisture. In moist weather, they may be found feeding at all hours; and after a sultry dry term, no sooner does the rain commence its fall than they are astir, be the time when it may. Lister is indeed rather too nicely discriminative here: he tells us that the Snails (Cochleæ) feed at all times of the day, especially of a rainy one; the black field-slugs almost only at sunset, but the cellar-slugs not before midnight.†

* Zool. Journ. v. 30.

† Exer. Anat. de Cochleis, p. 89.

LETTER XX.

ON THE REPRODUCTIVE FUNCTIONS OF THE MOLLUSCA.

The doctrine which taught us that insects and worms were the offspring of mud and slime, or the natural products of the corruption and fermentation of animal and vegetable matter, was applied with equal confidence to explain the origin and propagation of oysters, slugs, and snails; * and even after the true theory, that every living thing proceeds from a parent like itself, had been established apparently by the numerous experiments of Redi, and by the progress of a rational physiology, there were not wanting some advocates of the wisdom of foregone times who continued to entertain the elder hypothesis. Father Philippo Buonanni, a learned Jesuit, was one of these. In his "Recreation of the Eye and Mind," published in 1681,—"it being a pretty large volume containing the natural history of all the snail kind," after an attempt to throw suspicion over the experiments of Redi, he declares his belief "of their being equivocally produced out of putrefaction," for which, says his candid critic, "he brings little proof besides the well-known reasons and authority of Aristotle." And this authority was so great, and vulgar prejudice so strong in its favour, and observation on these creatures so little advanced, that when an anonymous author, of whose work there is a short account in the Philosophical Transactions for 1693, opposed the Italian Jesuit, not with argument but with a simple observation, having seen the young snails issue from their eggs which he had found in his garden, he was afraid to give publicity to the fact without the evidence of witnesses. "This discovery being very plain and remarkable, he called in to see it many learned persons, and some of good quality, whom he names, that the truth of his asseveration may be out of dispute."—Beyond dispute it is now, and has long been, for although some recent attempts have been made to revive the ancient

* The reader who wishes to see how this opinion was argued may refer to Rondeletius de Piscibus.—"De Piscibus sponte nascentibus."—Lib. iv. c. iv.; or *Hist. des Poissons*, p. 83.

opinions of spontaneous generations, this no one has ventured to apply to any of the class of Mollusks, which are too well known in this respect to be longer the subjects of the dreams of speculative experimentalists.

Indeed, you will find in no class of animals more variety or curious complexity of the generative system than in the Mollusca; and it is a subject which has greatly exercised the comparative anatomist. It would, however, be impossible to give you a correct view of this structure and its numerous variations, without entering into details inconsistent with my plan; and I mean in consequence to confine myself very much to such facts as have reference to function—to their manner of depositing and protecting their ova and young, and to some phenomena exhibited by these in their developement.

In order to give some arrangement to our facts we may divide molluscous animals into (1) The Monœcious, in which there is no distinction of sex, but where every individual of the species has the same structure of its reproductive organs; (2) The Diœcious, in which the sexes are distinct as in the higher animals; and (3) The Hermaphroditical or Androgynous, where each individual has the male and female parts conjoined in its person, but to whose propagation a sexual union is nevertheless necessary.

I. MONŒCIOUS MOLLUSCA.

The Tunicata, with a few exceptions, are monœcious. In the genera which are permanently fixed to their sites, the ovum, previous to its expulsion from the matrix, has undergone such a degree of developement, that, on its birth, it has the form and semblance of a minute tadpole, and is endowed with very considerable locomotive powers. (Fig. 69.) We are indebted to M. Sars,* and to Audouin and Milne-Edwards for the discovery of this singular larva in the compound Tunicata;† and Sir John G. Dalyell has shown that the larva of the single species is precisely similar. He calls it a spinula from its peculiar shape; and he tells us that it has the strongest resemblance to the tadpole, not merely in figure, but also in motion. "A large head, almost opaque, with a black internal speck, declines into an attenuated flattened tail, with indistinct indications of segments and fins, or cilia. It wriggles through the water chiefly by

* Beskriv. 69, pl. 12, fig. 34.
† Litt. de la France, i. 72, 73.

aid of its tail, like the tadpole." Moving about in this manner for a few hours or days, the time probably regulated by the temperature of the circumfluent water, or by specifical ordination, the time comes when the law of nature compels it to settle and unfold the character of its species. The head is then applied to the site chosen for the future evolution; it enlarges and adheres by three short budding radicles; and, curiously enough, the tail which, during the process of fixation, had been held upright and stationary, is now moved violently, as if the creature were struggling to regain its liberty. "At this juncture the vibrations of the tail become so rapid, that, like those of a cord in tension, its figure is hardly discernible by the eye. At length quiescence follows; some diffusing matter escapes from the margin of the flattened head, and the spinula is rooted irreversibly to the spot." The growth goes on—a dark nucleus is substituted for the adherent head, the base enlarges irregularly, the tail is absorbed and disappears, and two nipples, the beginnings of the oral and anal apertures, rise from the surface, and complete the metamorphosis of the tadpole moving larva into the mammiform fixed Ascidia.* Thus, you observe, that, by giving them active and unconfined larvæ, the Creator diffuses the species; and to these fixed animals gives possession of a tract of coast not less extensive than that occupied by their nomade relations.

Fig. 69.

Savigny, whose opinions are always entitled to respectful consideration, believed that the egg of the compound Tunicata was itself a composite body, organized and developing itself in the pattern peculiar to each species. He appears to have been led to this remarkable conclusion by the examination more especially of the reproductive germs of the Pyrosoma. In this animal the eggs, when still very minute, detach themselves from the ovary in succession, one by one, and place themselves between the intestine and the bottom

* Rare and Remarkable Anim. Scot. ii. 150, 151.

of the tunic, where they continue to grow and develop up to the period of their final expulsion. At first they are globular, perfectly white and transparent, and a round aperture can be distinguished; when a little larger this globule exhibits four reddish specks, the first visible sign of as many embryos, which, as they enlarge, unite to form a chain partially encircling the globule, and the ring is only completed at maturity. It is then, in fact, a new Pyrosoma already compounded of four animalcules, and about to assume an independent existence. But as yet the component animalcules, you will observe, are only four in number, while the adult Pyrosoma consists of some thousands of individuals; and the Botrylli and other compound Tunicata are equally multitudinous in the mass, while their embryos show even fewer numbers on their birth. Some authors would explain this increase with increase of ages by supposing that the few originals rapidly become pregnant, and deposit their ova in the common envelope, where they are hatched to become in their turn the parents of others that arrange themselves, in relation to each other, after the design imprinted on each species by Him who called them into existence, and determined probably by some peculiar conformation of the primary ovum. It obviously follows, on this hypothesis, that there are no prescribed limits to the growth of the compound Mollusk; so long as life endures and nutriment is supplied, the propagation of the constituent individuals will go on, and in a constantly increasing ratio, and to this increase of the common mass the death of the whole is the only check. But this is contrary to the fact. The number of animalcules which composes a system in the Synoicum may consist of ten but not of fifty; a system of the Botryllus of thirty and not of a hundred; and although in certain kinds of Pyrosoma the number appears to rise to several thousands, yet even these great assemblages have their prescribed enumeration which they cannot exceed. Savigny, therefore, maintains that the compound Mollusk, with all its component animalcules, results alone from the gradual and successive developement of the compound egg, which is consequently supposed to include in one envelope just as many germs as there are to be future individuals. These germs are developed in a fixed succession, the first deriving the materials of their growth from their parent and from the ovum itself; and by the nutriment provided and supplied by these after their birth the others are probably stimulated on to evolution.*

* Mem. sur les Anim. s. Vert. ii. 58, 59; 121-2, and 124.

These views of Savigny have been not only not confirmed, but they are disproved by the observations of Milne-Edwards and of Sir John G. Dalyell, who find that the embryo and larva of the compound Tunicata is as simple as that of the single Ascidia, and so like it in structure, form, and deportment, as to need no further description. The character of the compound species depends on the law which regulates the evolution of its embryo, and this is carried out by the successive growth of germs or buds, which Nature has ordained shall be a necessary sequence of its own life. Becoming fixed to their extraneous site, the embryos are soon observed to shoot out, from one or more determinate points in their base, short papillæ, or, as in the social tribe, a lengthened stolon, which, by an imperceptible growth, soon becomes a perfect organism in all respects like unto its egg-parent; and no sooner has it attained individuality than it again sends forth its pullulating radicles, each to become like the original, and each fit, in due time, either to augment the population of the mass to which it is associated, and of which it is a native; or to propagate its species by the engendering of an ovarian egg and tadpole larva.* There is nothing peculiar in this mode of increase. The polype that lives in a compound mass, or which sends up new polypiferous offsets from its base, and the plant which overruns a soil with shoots pushed out on all sides of it, afford analogous examples.

I have now a rarer and more singular mode of propagation to bring under your notice, and yet its anomalous course need not shake your faith in its reality. The student of these lower tribes soon becomes familiar with miracles; and uncommonness, or even want of analogy with other phenomena, is no bar with him to the fair discussion and reception of a fact.

> "Multa tegit sacro involucro natura; neque ullis
> Fas est scire quidem mortalibus omnia: multa
> Admirare modo, necnon venerare; neque illa
> Inquires, quæ sunt arcanis proxima."

The Biphores or Salpæ (Fig. 43, p. 219), constitute one of the most remarkable and abundant genera of compound Tunicata in temperate and tropical seas, where they are seen swimming or floating about, during the calms that soothe the glistening surface, in crystalline masses of many

* Milne-Edwards, sur les Ascid. Comp. 41, &c.; Dalyell's Rare and Remarkable Anim. Scot. ii. 164.

a varied pattern, painted with delicate tints. In some species from five to sixteen individuals will be united organically in a rosaceous fashion; other species form a lengthened ribbon, the concatenated individuals being placed side by side, and hence arranged transversely; others have the ribbon formed of two parallel rows of individuals agglutinated back to back, so that the constituent of one row may dovetail itself between two of the other; and others again form chains, in which each member is stretched in the direction of its length, and attached to the one before and the one behind it. The latter are the sea-serpents of the common sailor, for they elicit his notice, as well as the curiosity of the more scientific voyagers. With these compound masses there are found intermingled many single and isolated Salpæ, which were long believed to be either distinct species, or the separated individuals of a colony; for, it was said, that at a certain age, perhaps at full maturity, the chain naturally dissolved, and every link segregated itself.*

The discovery of M. de Chamisso—a German naturalist—lays open another view of the relationship of the single to the compound organism, and one unseen before in the wide field of physiology. Here the offspring do not resemble the parent at birth, and they remain dissimilar during their whole life, so that the relationship is not apparent until a succeeding generation. The son resembles not the father, but the grandfather; and in some cases the resemblance reappears only at the fourth or fifth generation, and even later. This singular mode of propagation has received the name of "alternating generation." It was first observed amongst the Salpæ by Chamisso. The Salpæ are viviparous, and each species is propagated by an alternate succession of dissimilar generations. One of these generations is represented by solitary or isolated individuals; the other by aggregated individuals united in groups such as I have described. Each isolated individual engenders a group of associated individuals, and each of these produces in its turn a solitary individual. The solitary individuals are then multiparous, and the associated ones uniparous. This is not the only difference which exists between these two alternating generations; for if we compare the individual in the chain to the naturally isolated one, we find differences in their external form as well as in several peculiarities of their internal organization. A species then has two forms, and you at once perceive how this fact reduces their number in

* Rang's Manuel, p. 358.

the catalogue of systematic naturalists, and complicates the identification of them.*

The Brachiopoda are all monœcious,† every individual of every species being "sufficient to its own felicity." The same is the case apparently with the majority of the ordinary acephalous bivalves, but the exceptions are yearly increasing under the dissections of the comparative anatomist, who has proved several of them to be bisexuous, although the distinction between the male and female does not appear in any external character either of the animal or shell. Some, indeed, of the earlier naturalists discriminate with care between male and female Solenes, but the supposed sexes were in fact either species of different genera, or the siphonal tubes were misinterpreted in their office; ‡ and as little regard would be paid to the fisherman, who believes the oyster to be double-sexed, were it not for the particularity of his observation: "The male oyster is black-sick, having a black substance in the fin; the female white-sick (as they term it), having a milky substance in the fin." § If there is any mistake in the observation it lies in misnaming the sexes, for the latter is the male. Willis and Lister || were of this opinion; and Deslandes imagined that the females could be distinguished by a delicate edging or border surrounding their bodies,—in which he is wrong. Lister asserts of the fresh-water mussel, that the males and females are in nearly equal proportion; and he found the ovary of the female full

* See Steenstrup on the Alternation of Generations, trans. by Busk, p. 38–51; Krohn in Ann. des Sc. Nat. (1846), vi. 111.; Agassiz and Gould's Princ. of Zoology, i. 128; Forbes and Hanley's Brit. Mollusca, i. 47—50. Chamisso's proposition is: That all solitary Salpæ produce associated ones or chains; and on the contrary, that all the associated Salpæ are parents of solitary ones, and these again of the associated, and so on. "The generations of the Salpæ consequently are alternately solitary and associated, so that a Salpa mother," to use Chamisso's familiar expression, "is not like its daughter or its own mother, but resembles its sister, its granddaughter, and its grandmother."—The doctrine has been extended to other classes of the lower animals by Steenstrup, whose attempt to make it embrace the Ascidia and compound Tunicata seems to me a hasty one. I trust in saying so I may not incur the hearty reprehension of Professor E. Forbes. "In vain Chamisso offered the most careful researches and minute details of his observations. The heavy-headed in science stigmatised him as a poet and romancer, who carried his day-dreams into the world of reality, and thus conjured up his wonderful vision of Salpæ. More than twenty years had to pass away before his statements were fairly treated."—*Brit. Moll.*, i. 48.

† Owen in Trans. Zool. Soc. Lond., i. 152.

‡ Phil. Trans. 1684, p. 834.

§ Sprat's Hist. Roy. Soc., p. 309.

|| Exerc. Anat. tert. 9.

of innumerable ova forming a granular fluid, at the very time when the male was turgid with a white milk of the consistence of honey.* Baster not only believed in the bisexual nature of the oyster but of the mussel also, which, he tells us, is big with ova in April and May. At this time he observed some of them to eject a milky fluid diffusible in water, and hence he presumed they were masculine; others, at a later period in May, were noticed to eject at short intervals, during the space of nearly two hours, oblong bodies not unlike the excrements of mice, which fell in a little heap within a short distance of their parent. After about six hours these bodies had become flat like a plate; next day they separated readily by a slight agitation of the water, and a few being placed under the microscope, it was seen that they were evidently the young of the mussel. The observations of M. Prevost, of Geneva, published in 1825, do not appear to be more conclusive than those of Baster. They relate to the Mya pictorum. "If, towards the spring," says M. Prevost, "we examine the organs of generation in some individuals of this species, we are struck at the first glance with the different products which they emit. While we find in some individuals a true ovary, and ova in abundance, in others the analogous organs, and similarly placed, contain nothing but a thick liquid of a milky colour, which under the microscope appears to be crowded with animalcules in motion. These marked differences are neither the result of chance, nor of a subsequent change in the condition of the ovary. The Myæ in which ova are found present no trace of the thick and milky fluid; and, on the contrary, those which possess this liquid produce no ova." From somewhat similar observations I find it stated that the genera Anomia, Teredo, Dreisseina, Venus, and Cardium, are also separately masculine and feminine; but surely Wagner has travelled fast to a generalization if it is from such limited data that he has concluded the class of bivalves to be, with very few exceptions, animals of distinct and separate sexes.† Mr. Garner, no mean authority, has come to an opposite conclusion, apparently questioning the accuracy of the observations which would seem to prove that even the genera quoted are bisexual. "There appears," says Mr. Garner, "every reason to believe that there is no difference in the individuals as to sex, and that the ova are discharged from the ovaries in a state fit to develope, without the necessity

* Exercit. Anat. tert. p. 9.

† Müller's Elem. of Physiology, trans. 857. Professor Owen has come to the same conclusion as Wagner. Lect. Invert. Anim. 287.

of the contact of any vivifying fluid; or, in other words, that they are fecundated before they leave the ovaries, by testes which must be conjoined with those organs. No distinct male organs appear to be present. Perhaps Home, who mentions their existence, has mistaken the excretory organs for them, as have many other anatomists. From what the author has observed in the Modiolæ and Mytili, he believes that the organs called ovaria do, at certain periods, secrete the seminal fluid, which impregnates the ova contained in them, and is then discharged as an excretion by the oviducts." *

The Conchifera of European seas are big with spawn usually in the spring, or at the commencement of summer, and some species are said to be fruitful more than once in the year. Previous to their expulsion, the young may be seen within the pellicle of jelly by which they are surrounded and enclosed, opening and closing their tiny valves, and moving on their axis in a rotatory manner;—"perhaps, when most lively, there are seven or eight volutions in a minute." † When ripe for an independent existence the loaded spawn is discharged from the oviducts, and carried from the body of the parent, partly by means of the motions of the closing valves, but principally by the force of the currents of the respired water. The young, speedily loosened by the dissolution of the jelly in which they were nurtured, are now disseminated through the water by ciliary movements, and by their own locomotive powers; for at this, the very spring-day of their existence, even the very oyster joys in its motility, the mussels roam at freedom, the stone-boring Pholas and Lithodomus seek out rocks unvisited by their progenitors, and the other burrowing tribes

* Charlesworth's Mag. Nat. Hist. iii. 439.

† This beautiful phenomenon was first observed by Leeuwenhoek, and well described by him in the pond mussel. "Some of these mussels I opened in the presence of the engraver, in order that, as soon as I had taken some of the young ones out of their receptacles, he might make a drawing of them, for were they suffered to stand but a few hours, their true figure would be lost. The unborn mussels being put into a glass tube and placed before the microscope, I saw with astonishment a most pleasing spectacle, for every one of them, each in its particular membrane or covering, had a slow circumvolution, and that not for a short space of time, but such turning round or rotatory motion was observable for three hours afterwards, and it was the more curious, because the young mussels, during the whole of their motion, constantly kept in the centre of their membranes, just as if one were to see a sphere or globe revolving upon its axis. This uncommonly pleasing spectacle was enjoyed by myself, my daughter, and the engraver, for three whole hours, and we thought it one of the most delightful that could be exhibited."—*Select Works*, i. 87.

scatter themselves abroad as instinct leads or chance directs, to continue their race in new localities.

A few genera amongst the bivalves are viviparous,—that is to say, the ova are carried from the ovary to be deposited in the interstices of the external laminæ of the branchiæ, where they are retained until the young are hatched and have acquired all the perfection of maturity. The pond and river mussels have this character, which is still more evidently developed in the little fresh-water Cyclades, and in the pretty sea-shore Kelliadæ. In the Unio and Anodonta, says Mr. Garner, the ova may be found for several months in the external branchiæ after leaving the ovaria, distending their organs in a remarkable manner. * The Cyclades had also been known to be viviparous for several years before Professor S. Nilsson discovered the peculiarity of organization provided for their temporary retention in Cyclas cornea. This is a peculiar membranous sac fixed above to the root of the branchiæ, and free in the gill cavity below. There are from two to five young in each little sac attached by a capillary navel-string holding the position of the byssus in other bivalves; and although the young in each sac are all alike and equal, yet young, various in age and in size, are found not only within the same shell, but even in the same gill.† The Kellia has its peculiar apparatus also. All other bivalves have the siphons, when there are any, at the posterior end of the shell, but the Kellia has a large siphonal tube in front as well as a short one behind, as was first pointed out by Mr. Alder.‡ Now there has been a good deal of ingenious disputation as to the function of this front siphon, but the anomalousness of its position seems at length to have been explained away by Mr. W. Clark, who has made the interesting discovery that it is an oviduct; and not merely so, but for some time a nidus also for the full developement of the testaceous young. "But," says Mr. Clark, "I shall not be surprised to find that Mr. Alder and myself have mistaken the use of this fold in Kellia rubra, and that it may minister to supply water to the viviparous colony deposited in the ovarium of the animal of this species, and also act as an oviduct and receptacle for the young, until they are sufficiently developed for exclusion. This idea arises from

* Charlesworth's Mag. Nat. Hist. iii. 441.

† Mollus. Sueciæ terr. et fluv. 97.—This reminds one of the curious ovarian sacs in the Unio irroratus as described and figured by Lea. On the genus Unio, p. 13, pl. 5, fig. 6, 7. See also Sowerby's description of Cardita concamerata in Zool. Journal, iii. 526.

‡ Trans. Tyneside Nat Club, i. 188.

having seen, when examining some Kellia suborbicularis in a saucer, several testaceous young ejected from the anomalous tube of one of the animals." Further observations confirmed Mr. Clark in this opinion. *

The bivalves, like the Mollusca in general, are capable of reproduction at an early age and long before maturity. Of the Cyclades the Rev. Leonard Jenyns says,—"they have the faculty of producing long before they are arrived at their full growth, and even some individuals which are themselves so immature as to possess hardly any of the distinguishing characters of the species, frequently contain young of a sufficient size to be seen from without through the transparent valves." † Oysters spawn when they are only four months of age, although they do not attain their full size until after the lapse of three or four years. And the prolificness of the class is prodigious. Leeuwenhoek reckoned that there were ten million embryo young in an adult oyster, Baster reduces the number to a hundred thousand, and the reduction might be allowed without much weakening our position, even had Poli not added his authority for its more abundant fruitfulness. He says that an oyster may contain one million two hundred thousand ova, and may give birth to the contents of twelve thousand barrels; so that the Rev. William Kirby, with a naïvete that might suit the author of a prior century, concludes hence that "Providence has thus taken care that the demands made upon them to gratify the appetite of his creature man, shall not annihilate the race." ‡ "In the dissection of an Anodonta undulata nearly three inches long," says Mr. Lea, "I met with the oviducts charged with about six hundred thousand (as nearly as I could calculate), young shells perfectly formed, both valves being distinctly visible with the microscope." Dr. Unger reckoned in a full grown Unio pictorum three hundred thousand embryos and young individuals; § and Sellius has made some calculations which prove an almost incredible fecundity in the Teredo. || These are sufficient and not exaggerated instances of the prolification of the Conchifera, which would

* Ann. and Mag. Nat. Hist. Ser. 2, iv. 143.—Mr. Alder has, however, questioned the uterine function of this siphon. Lib. cit. 245.

† Monograph from Camb. trans. p. 10. See also Brown in Edinb. Journ. Nat. and Geogr. Sc. i. 412, where he proves that Pisidium is viviparous.

‡ Bridgew. Treat. i. 257.

§ Edinb. New Phil. Journ. ix. 386.

|| De Tered. p. 15.—The calculation made by Leeuwenhoek of the number of young laid by the Common Mussel (Mytilus edulis) is to be disregarded, for he mistook a parasitical zoophyte (Flustra dentata) for the ova. Phil. Trans. abridg. v. 703; Select Works, i. 82. pl. 3. fig. 9.

consequently in a short century, fill our shallow lakes and rivers, and raise to the sea's surface the banks on its hollow bed, were it not for the numerous checks which oppose their increase, and retain in equipoise the balance between them and other entities and inorganic matter. In a single day, says Buffon, "a mass of oysters of several fathoms in thickness is often raised; the rocks to which they are attached diminish considerably in a short time, and some banks are entirely exhausted. The following year, however, furnishes an equal quantity, and not the smallest diminution appears."*

Before I leave this section of my letter I would warn you against the erroneous opinion of M. Rathke, which is that the little shells found in the gills of the fresh-water mussels are not their own fry but parasitical animals, which he elevates into the rank of a genus under the name of Cyclidium. M. Jacobson, a learned anatomist of Copenhagen, takes the same view. He shows that the shape of the little shells swarming in the gills is different from that of the presumed mothers, for it approaches to the triangular, and in each valve there is a small moveable and hooked denticle not found in the adult, and a bundle of very irritable filaments connected with the abdomen. Further, the fry in question are of the same size and shape in all the different species however various they may be in these respects; and their developement has no relation either to the season, or to the age of the individual in which they are contained, while their numbers seem to be enormous in proportion to the number of the species of which they are imagined to be the young. And Jacobson further deems it a too hard strain upon our faith to call upon us to believe that organs so delicately organized as the branchiæ are, could be destined to fulfil naturally the office of oviducts, and even of an uterus. And yet it must even be so; for in fact the whole progress of the egg from the ovary to the gills, has been traced by both competent and independent observers. Raspail concludes his argument against their parasitism by asking—"How can it be conceived that parasites should be contained in a parcel like the eggs of the Mollusca, and ejected by the animal itself?" †

II. DIŒCIOUS MOLLUSCA.

These may be conveniently divided into two classes, the first characterized by a perfect similarity between the male

* Nat. Hist. trans. i. 213.

† Cuvier's Analyse des Travaux de l'Acad. roy. des Sciences. ann. 1827. p. 73. Edinb. New Phil. Journ. v. 405.

and female to outward appearance; the second evidently marked by peculiarities in the structure of each sex. The first may be called the cryptogamous Mollusca, and the second the phænogamous, for the terms mark very well the distinction between them.

The cryptogamous Mollusca embrace the Tubulibranches, the Scutibranches, and the Cyclobranches, which together form but an inconsiderable proportion of the Gasteropods, for they are orders few in species; nor are the equally cryptogamic Heteropods more numerous in their tribes. They were until recently considered by our best authorities to be monœcious—a very natural error, for the proof of their being bisexual is derived entirely from microscopic anatomy, and is only to be found at certain seasons; the truth had, however, been suspected long before modern discovery proclaimed it decidedly. Adanson said that the limpets had separate sexes;* and Cuvier considered the opinion to be probable, and perhaps applicable to the genera Capulus, Crepidula, and Calyptræa.† Mr. J. E. Gray convinced himself of the fact by personal observation in all these genera before others had given their assent;‡ and now there seems to be no dispute in the matter. The female deposits her numerous ova enveloped in a jelly on its expulsion from the body, and in their evolution, these ova appear to exhibit no remarkable phases.

The phænogamic diœcious Mollusca embrace all the pectinibranchial Gasteropods. You may remember being told that these are either phytivorous or zoophagous, and these tribes differ very remarkably in the mode of their generation.

The Phytophaga lay their eggs merely enveloped in a mass of jelly, just firm enough to retain its form in the water, and which, deposited on the fronds of sea-weed, or on the surface of rocks and stones, adheres to them with tenacity.§ The form of the mass is roundish, oval, or oblong, and it may be more complex in some. I have often seen, on the common wreck of our shores, a white gelatinous ring, with a narrow break or interruption on one side, which I believe to be the spawn of the Trochus cinerarius. The ova are always immersed in the mass which forms a common bed to the whole; but besides each ovum,

* Hist. Nat. du Senegal, 31.

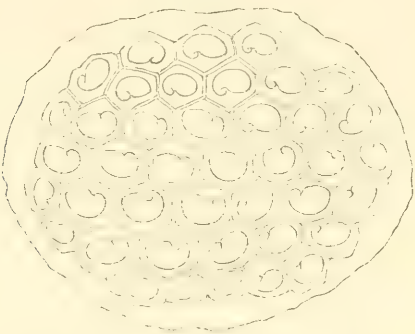
† Mem. xviii. 18, 20, 21 and 22.

‡ Edinb. Journ. Nat. and Geogr. Sc. iii. 53.

§ Baster has given rude figures of the spawn of our common Littorinæ in Opusc. Subs. 1, pl. 5. fig. 4, 5.

or at most three or four ova, has its own proper globule of jelly, contained within a skin or pellicle of the greatest tenuity, and which isolates it from the rest.* The annexed figure (Fig. 70) exhibits this disposition as we see it in

Fig. 70.



the spawn of the Periwinkle (Littorina littorea); and you perceive also that the minute embryos are already covered each with its shell, so that any metamorphosis they undergo is early and speedily completed.

A few species of these phytivorous Gasteropods are viviparous, the spawn being lodged in the branchial cavity until the young are fitted for a separate existence; and we find some oviparous and some viviparous species in the same genus. Thus the common Periwinkle (Littorina littorea) has the economy of the first, and the Littorina rudis that of the second. The Paludina vivipara affords another illustration of the same fact; and the fœtal shell of this, as Swammerdam ascertained, is armed with crystalline spines arranged in regular rows on the whorl, while the mature shell is even and destitute of armature. It is almost the only instance known amongst Mollusks of the embryo shell exhibiting an exterior structure different from the adult. Spallanzani affirms that young individuals of Paludina vivipara taken from the mother, and kept always in a state of isolation, yet produced in due time young,—a fact from which you are not to infer, with him, their monœcious nature, which anatomy disproves, but that a single impreg-

* The embryo has the same rotatory motion in the ovum of these and other Mollusca as that described in the spawn of the bivalves. See Carus as translated in Zool. Journ. iv. 257.

nation is sufficient for at least two generations, as we know to be the case with the Aphides or Plant-lice.*

The zoophagous Gasteropods, living usually in deeper water, where the spawn is more exposed to forage, enclose their eggs in capsules of a horny texture, and often so curiously connected and contrived that nowhere will you find finer displays of the Creator's preserving care over all his works. The ova, while passing from the body, and while still in the oviduct, are included within a glairy excretion prepared in an accessory glandular apparatus, and which is moulded into a coriaceous pouch of very variable figure according to the species. It is either single or compound. In the former case, every pouch, as it is extruded, is attached by the animal, one by one, to the rock chosen for the precious trust; in the latter case, the cluster of oviferous receptacles is expelled in one common mass: and when you are told that this is frequently much larger than the shell of the parent, you may wonder how this can be? And so did Dr. Job Baster. "I have often wondered," he says, "how a univalve could lay an ovary exceeding, by five or six times, its own size. But the explanation is obvious enough, for it is proportionably small, and of a soft glutinous consistence on its first deposition; it grows after its expulsion, and keeps pace with the growth of the ova and young, and at the same time hardens to a more solid and coriaceous texture. I have seen the receptacles of the Purpura lapillus when they were less than a line in height, and their colour was also then much darker than it is at maturity." The process of laying is very well described by a correspondent of Sir E. Home's as observed by him in the Turbinella pyrum. "A friend of mine," says Sir Everard, "saw the female shed her eggs; a mass, apparently of mucus, passed along the deep groove in the lip of the shell in the form of a rope, several inches in length, and sunk to the bottom: this rope of eggs, enclosed in mucus at the end last discharged, was of so adhesive a nature, that it became attached to the rock, or stone, on which the animal deposited it. As soon as the mucus came in contact with salt water, it coagulated into a firm membranous structure, so that the eggs became enclosed in membranous chambers, and this connected nidus, having one end fixed and the other

* M. Alex. de Nordmann found that some Nudibranchial genera laid fruitful ova without the individual having had any society with another of its species. Ann. des Sc. Nat. (1846) v. 136. Being of androgynous structure, this fact is more readily explained than it is in Paludina. See Alder and Hancock's Nudibr. Mollusca, iii. fam. 3 pl. 7 and 8.

loose, was moved by the waves, and the young in the eggs had their blood aerated through the membrane, and when hatched they remained defended from the violence of the sea till their shells had not only been formed but had acquired strength."*

These egg-capsules are so diversified in their forms and mode of aggregation,† that M. A. Lund, a learned Danish zoologist, has reduced them into classes and orders in a manner well calculated to impress distinctly their diversity on the memory. The arrangement is as follows:—

CLASS I.

THE MASS OF EGG-CASES IRREGULAR. (The egg-cases form in their aggregate masses of indeterminate shape.)

ORDER i. *Egg-cases coherent:* The cases are attached to and upon each other.

Family 1. The egg-case opening by a fissure of the margin.

2. The egg-case opening by a circular aperture furnished with a membranous lid.

ORDER ii. *Egg-cases adherent:* The cases are attached to a common basal membrane, by which they are rooted.

Family 1. The egg-case opening by a fissure of the margin.

2. The egg-case opening by a circular aperture furnished with a membranous lid.

* The egg-cases sessile, or directly attached to their common base.

a. Tubiform.

** The egg-cases pedunculated, or attached to their common base by a pedicle.

a. Egg-shaped.
b. Cup-shaped.
c. Funnel-shaped.

* Comp. Anat. iii. 396.

† The various *Tubulariæ* represented by Esper in his "Pflanzenthière," in plates 11 to 16, and 18 to 26, are the egg-cases or embryo sacs of zoophagous mollusca.

CLASS II.

THE MASS OF EGG-CASES REGULAR. (The egg-cases form in their aggregate masses of a determinate figure.)

ORDER i. *Egg-cases coherent.*

ORDER ii. *Egg-cases adherent;* the cases are attached to a common body serving as an axis.

* The egg-cases attached all round the axis.

** The egg-cases attached along one side of the axis.

a. Sessile.

b. Pedunculated.†

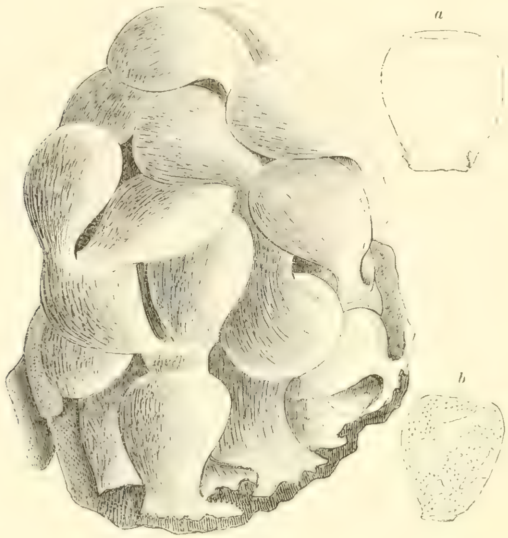
I shall now describe a few of these egg-cases, or "concamerated nidus," as Sir Everard Home calls them. Those of our common Whelks belong to M. Lund's first family. That of the Buccinum undatum Ellis names "Sea wash-balls," for they are "used by the sailors as soap to wash their hands;" but our fisher-lads of the north countrie call them "fyke," because, with the dried powder of them, they torment their fellows by slyly insinuating it between the skin and clothes, when it raises a very intolerant degree of itching. The common nest is composed of numerous coriaceous pouches of a compressed globular shape, united, by a strong ligament, into a roundish mass, which, in size and general appearance, may be aptly compared to the nest of some humble-bees. Each pouch, "about the size of half a large pea," contains about four young, and these, when about to be hatched, have already four whorls, and exhibit, in tolerable perfection, the character of the adult shell.‡ The nidus of the Fusus antiquus is more regular and curious (Fig. 71): when of full size it forms an obtuse cone about three inches in height and two in diameter, attached firmly by a broad basis to rocks in deep water. This cone is made up of a number of large pouches, joined together by a strong cartilaginous band or skin in a regular manner: each cell is shaped something like the human nail, convex outwardly and concave on the inner side, with a strong horny outer coat slit along the upper edge, but the aperture so narrow

† Ann. des Sc. Nat. (1834) i. 93.

‡ Ellis Corallines, 84, pl. 32, b, B. Baster Opusc. Subs. i. 14. tab. 5, fig. 2. J. E. Gray in Charlesw. Mag. Nat. Hist. i. 248.

that it affords entrance to nothing excepting the water which is necessary to aërate the growing young (*a*).* Within this pericarp, and only very loosely connected with it, there is

Fig. 71.



a bag of a similar form (*b*), but everywhere close, and of such a thin and pellucid membrane that it presents no obstacle to the influence of the oxygenating medium. At first its contents are fluid and granular, but soon opacities are to be discovered in several places, and ultimately from two to six young are developed in each pouch, which can only make their way out, at the appointed time, by a rupture or dissolution of the inner bag. Still more singular are the concamerated nests of many exotic zoophagous Gasteropods. Here is the figure (Fig. 72) of a portion of one which seems to have afforded Mr. John Winthrop the subject of the following notice:—"Moreover," he says, in describing some curiosities he had sent to the Royal Society, "there are some of the matrices, in which those shels are bred, of which the Indians (American) make the white wampanpeage, one

* Baster says that it admits neither air nor water—"quæ aeris aquæque marinæ ingressum arcet, sed quæ exitum fœtu maturo ex ovis concedit."—*Opusc. Subs.* i. 37. tab. v. fig. 3.

sort of their money: they grow on the bottom of sea-bays, and the shels are like Periwinkles, but greater. Whilst they are very small, and first growing, many of them are within

Fig. 72.

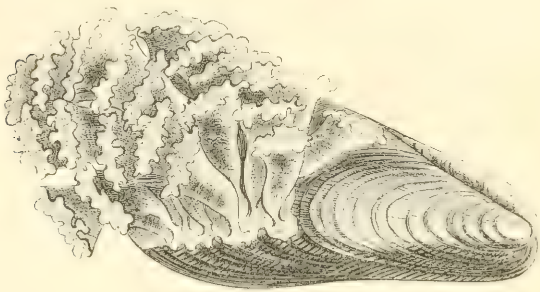
one of the concave receptacles of these matrices, which are very tough, and strong, so contrived, that they are separate from one another, yet so, that each of them is fastened to a kind of skin, subtended all along to all these cases or baggs."* Ellis has figured and described the same, or a very nearly allied one, with his usual accuracy:—"The ovaries, or matrices, are of a compressed oval form, and some of them of the shape of the Limpet or Patella, but flatter at the top. These are united on one side to a tough pliable ligament, so near to each other as to seem to lie on one another. On the front edge, opposite to where they are fastened, is the arched door, by which the young ones, when they are capable of providing for themselves, make their retreat into the sea. The valve that covers this door during their minute state, is a most curious contrivance to preserve the tender animals from the sea-water till they are able to venture into it. During their confinement, they are covered with a slime like the white of an egg; which, no doubt, nourishes and promotes the growth of the young animals.—If we attentively consider this string of ovaries, we shall be apt to conclude that both they, as well as the animals, grew after they were deposited by the parent Whelk; for they appear by much too large for even the largest of this tribe ever to have contained. At first sight, they have the appearance of something belonging to the vegetable tribe, and are not unlike the strings of seed-vessels of the Hop hornbeam."†

* Phil. Trans. 1670, p. 1152; also vol. xvii. p. 871.

† Corallines, 85, pl. 33. fig. a, A. Phil. Trans. abridg. iii. 573. The nidus is that of the Murex canaliculatus, Linn.=Pyrula canaliculata. Brug.

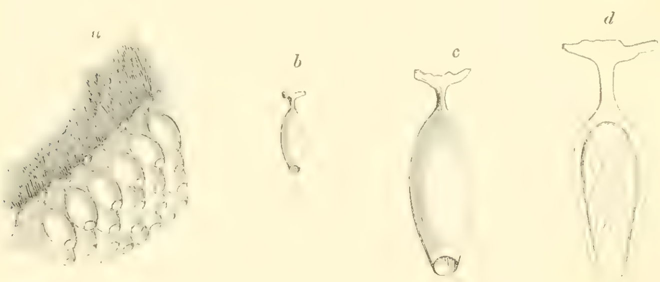
This curious nest is an example of M. Lund's second Class, Order ii. **; and the very beautiful one figured (Fig. 73) on the shell of a mussel illustrates the second Order of

Fig. 73.



his first Class, Family 2*. I found it in a small collection brought home, I believe, from the East Indies,* by a sailor to ornament the cupboard of a humble dwelling. Each capsule of the close-set cluster is inversely conical, and nearly an inch in height, with its top elegantly cut in the manner of the embrasure of some ancient fortalice. It contrasts strongly with the neat simplicity of the egg-case of the Purpura lapillus (Fig. 74), which Ellis calls the "sea-

Fig. 74.



cup."† The nidus of this common Mollusk is in the form

Gould's Invert. Massachusets, p. 295, fig. 206. See also Lister Hist. Conchyl. pl. 879 and 881. Owen's Lect. Invert. Anim. 309.

* In Baster's Opusc. Subs. i. tab. vi. fig. 3, a very similar one is represented. It is copied from Browne's Hist. of Jamaica.

† Ellis Corallines, 87, pl. 32, fig. c. c.

of an elliptical vase supported on a short stalk, and adhering by a broad base to a common membrane spread over the surface of the shelving rock, from which it hangs in clusters of considerable extent, sometimes covering a space eight inches square. "When they are first taken out of the sea, they are of a bright semi-transparent yellow colour, of a horny tough nature, containing a viscid substance, with many orange-coloured seeds, or egg-like particles, in the upper part of each cup," which, you will observe from (Fig. 74, *d*, is lined with a thin inner membrane similar to what we have described in the ovarian capsule of Fusus antiquus; and remember that every nidus of every Gasteropod of this tribe is similarly constructed. In due time, the "orange-coloured seeds" have become fœtal Purpuræ, when the apex of the cup rises to a more convex form, becomes thinner, "and after about four months opens, and the young prisoners escape into the surrounding medium, and take refuge in the crevices of the rocks, or amongst mussels, balani, &c., which are attached to them. The young leave the cups gradually, and sometimes a fortnight elapses between the exit of the first and the last, and they are of different sizes; they have all the peculiar habits of the adult ones, such as the remaining out of the water for long periods: this I observed in many that I reared in a dish in my house; some of them, also, were of a purple colour." † Here is the effigies (Fig. 75) of another nidus of equal simplicity, and a member also of Lund's Order i., Class II. It belongs to the Nassa reticulata, and all the specimens I have seen have been deposited on the fronds of shore sea-weeds, or on the grass-like leaves of the Zostera marina, arranged sometimes in no obvious order, but usually in a row so close that, when depressed, they overlie each other like the brass scales of the cheekband of a hussar. Mr. Peach compares them to the spade on play-

Fig. 75.

† Peach in Report Brit. Assoc. 1842, p. 66; and in Ann. and Mag. Nat. Hist. xi. 29. pl. 1, fig. 1—3. I entirely dissent from my friend's conclusion that Ellis believed the sea-cup to be the nidus of Littorina littorea. No

ing-cards.* They are compressed pouches, nearly of the size of a silver penny, supported on a very short pedicle, and opening on the top to give a doorway to their embryos.

You may remember that some Mollusks which have an entire, and not a channeled or notched, aperture to the shell, are nevertheless zoophagous; and these further evidence their resiliancy from the phytivorous families, with which they have too long been associated, by the character of their egg-repositories. It is true these cannot well be reduced to any of M. Lund's classes, but they are concamerated nidi of a peculiar character. The Naticæ afford examples. Their egg-receptacles were long believed to be a zoophyte, although Ellis's knowledge prevented him from participating in the mistake: the mass appeared to him "to be a collection of sand, united by the viscid matter of some sea-insects, and disposed in a flat thin surface, full of small cavities, where the insects have been."† Its true nature seems to have been first suspected by Mr. Boys, and fully demonstrated by Mr. J. Hogg by hatching the young of a pretty Natica found on the English coast. Dr. Gould thus describes the nidus:—"It is a mass of sand glued together into the shape of a broad bowl, open at the bottom, and broken at one side. Its thickness is about that of an orange-peel, easily bent without breaking when damp, and when held up to the light will be found to be filled with little cells arranged in quincunx order. Each of these cells contains a gelatinous egg, having a yellow nucleus, which is the embryo shell. It is found plentifully at Midsummer on every sandy flat where any species of Natica resorts."‡—Yes! the Natica has a sand wherein to bury for a time its germinating young, but where is the oceanic Ianthina to secure its procreant nest that it may not be, like the weed, cast away where'er the rude imperious surge may prevail? It sus-

doubt, Ellis says, "So that we may properly look upon this sea-cup as the ovary to the Periwinkle shell-fish;" but the name was indubitably not restricted by Ellis to the Littorina, being used, as defined by Johnson, to designate "a small shell-fish." Many of the fishermen in my neighbourhood still so apply the name to the Purpura lapillus, and Ellis's figure proves he knew the nidus to belong to this species. Lund was, however, ignorant of the fact. I knew the relation between the shell and cup so early as 1815, and my impression is, that my knowledge of it was derived, not from personal observation, but from my honoured teacher Professor Jameson of Edinburgh.

* Report Brit. Assoc. 1843, p. 129. Ann. and Mag. Nat. Hist. xiii. 204.—The ova capsules of Fusus norvegicus and F. turtoni resemble this in simplicity. Howse in Ann. and Mag. Nat. Hist. xix, 162, pl. 10, fig. 3 and 9.

† Corallines, 74.

‡ Invert. Massachusets, 232.

pends the ovigerous capsules from its float! From the float? Yes*—the snail is taught to fix its ovigerous capsules, which are sometimes numerous, to the under side of the "float," where they are suspended by little pedicles in a line, or after a pattern peculiar to each species. It is said that the mother then detaches the float loaded with its teeming burden; and suspended, in this way, near the surface, the embryo young receive the influence of the life-giving air, and are matured; and thus the race is preserved and multiplied.† Here you have the pretty fable of the Halcyons almost realised; and in your reflections on the real you may arrive at the old conclusion, that "Heroum fabula veris vincitur historiis."

All the Cephalopods belong to the diœcious section of mollusca, and the sexes of at least many species are distinguishable by a marked difference in the form of the body. Risso says that the body of the male Octopus is more conical than that of the female;‡ and the distinction is still more marked in the Loligines. The male of Loligo subulata has the extremity of the body prolonged behind by a fleshy tail a half longer than the female; and as this dissimilarity extends to the cartilaginous pen or back-bone, a naturalist ignorant of the sexual distinction might be led to mistake the sexes for distinct species.§ The males of the Octopus are also less numerous than the females in the proportion, as estimated by Cuvier, of about five to one;|| but the grounds on which the estimate is founded are uncertain, nor can it be safely applied to the other genera of Cephalopods.

The Cephalopods are, without any exception, oviparous;

* A fact first ascertained by Sir Joseph Banks:—"We also took several of the shell-fishes, or testaceous animals, which are always found floating on the water, particularly the Helix ianthina and violacea; they are about the size of a snail, and are supported upon the surface of the water by a small cluster of bubbles, which are filled with air, and consist of a tenacious slimy substance that will not easily part with its contents. The animal is oviparous, and these bubbles serve also as a nidus for its eggs."—Sir Joseph Banks, *in Kerr's Collect. of Voyages and Travels,* vol. xii. p. 370. edit. 1824.

† Rang's Manuel, 197, pl. 5, fig. 3. Zool. Journ. iii. 265. Mrs. Gray's Fig. Moll. Anim. i. pl. 48. Sir Everard Home has published a beautiful figure of the shell of an Ianthina covered with a much twisted and beaded filament formed by a long series of membranous capsules or cells, each cell enclosing a single ovum. This Sir Everard unhesitatingly (yet erroneously) describes as the "camerated nidus" of the Ianthina.—*Comp. Anat.* iii. p. 398, and iv. pl. 141.

‡ L'Europ. Merid. iv. 5.

§ Ann. des Sc. Nat. (1842) xviii. 259.

|| Mem. i. 31.

and the ova, notwithstanding all the tales of the earlier naturalists to the contrary, are not made prolific until after their expulsion from the female. In their passage from the ovary they receive a coating of a gelatinous fluid secreted by a peculiar gland, and insoluble in water, but which swells out greatly after the deposition of the eggs. These are always clustered, and the pattern of the cluster varies in the different families: in the Sepia it resembles very exactly a bunch of black grapes, both as to size and colour;* in the Octopus they are irregularly heaped in bunches attached to algæ; and in the Loligo, or Calamary, they are imbedded in a regular series of cells in a pudding-like gelatinous intestine, from eight to twelve inches in length, many of them being united together by a ligament in a common centre, so that the cluster, when mature and entire, may be compared to a woollen mop. At first the contents of the egg are colourless and fluid, and apparently homogeneous; but shortly after their impregnation, a speck becomes visible in the centre, and the young fœtus, drawing nourishment from the yolk through its slender cord, grows apace, and has assumed a recognisable form before the yolk is consumed, and before it is ready to burst through the thin membranes which contain and protect it.† It is probable that the female brings forth once only during the year, but the number of eggs laid is very considerable. Bohadtch has calculated that from a cluster of the common Loligo, of the average size, there are not fewer than 39,760 young ones produced.‡—The males, if we are to credit ancient story, are "very constant husbands, accompanying their females everywhere;" and they have their attentive care very ill requited. "The males of the cuttles kind," says Pliny, "are spotted with sundry colors more dark and blackish, yea, and more firme and steady than the female. If the female be smitten with a trout-speare, or such like three-forked weapon, they wil come to aid and succor her: but she again is not so kind to them, for if the male be stricken she will not stand to it, but runs away."

* Boys in Lin. Trans. v. 231. There is a figure of a cluster in Rondelet Hist. des Poissons, i. 368.

† Dr. Coldstream has given a minute description of the eggs of Sepia officinalis in Proc. Zool. Soc. Lond. i. 86, an. 1833. See also Cuvier in Ann. des Sc. Nat. xxvi. 69.

‡ De Anim. Marin. 161. Tab. xii. of this work contains a tolerably good figure of the clustered ovigerous mass. See another in Cyclop. Anat. and Physiology, i. 559. fig. 241.

III. HERMAPHRODITICAL MOLLUSCA.

It is a common remark that the most improbable fictions of the novelist meet their counterparts in the romance of real life; and it may be said with at least equal truth, that the wild creations of the poet find themselves realized among the structures of organised beings. Invention has not gone beyond what is actuated. Men who carried their heads under the shoulder are not more eccentric than the creatures which carry their legs and arms on their head; and we can instance whole tribes of animals rivalling the nations which were feigned to have their mouths in the breast. When the poet sang the metamorphosis of Hermaphroditus and Salmacis, and incorporated them in one, he imaged a monster which finds indeed no parallel in higher organisms; but amongst the Mollusks there are hundreds which, if known to him, might have suggested and almost justified the fancy. "Beyond those Nasamones," says Pliny, "and their neighbours confining upon them (the Machlyes) there be found ordinarily Hermaphrodites, called Androgyni, of a double nature, and resembling both sexes, male and female, who have carnal knowledge one of another interchangeably by turns, as Calliphanes reports."* An exact description this of some tribes of mollusks which border on the diœcious Gasteropods. John Ray discovered, in the gardens of Cambridge, that the common snail was of the nation of the Androgyni,—male and female, every individual having the peculiar organs of both sexes. Subsequent researches have shown that this structural union prevails, with a very few exceptions, in all the land and fresh-water snails which breathe the air uncombined, in all the nudibranchial Gasteropods, in the Inferobranches and Tectibranches, and in the Pteropods,—together constituting a very considerable section of the Mollusca. But although really bisexual, it is also true that no individual of these many tribes can impregnate itself; the union of at least two individuals is necessary for the propagation of the species: and it is asserted that though either of the two can act the part of the male or of the female, yet that one of them only is made pregnant from one union. I have said that at least two individuals are required to unite, and you may notice with surprise the limitation, and probably deem the phrase a mere pleonasm, but it is not so. In the lacustrine pulmonated Mollusca, represented by the Limneus and Planorbis,

* Holland's Plinie, i. 154.

the disposition of the sexual organs is such that the animal cannot not only fecundate itself, but even "mutual impregnation between two individuals is impossible. To complete the purpose of nature, the animals require to arrange themselves in lines or chains in a certain position, so that the sexual organs may be in contact, one with the male organ in connection with the oviduct of the nearest adjacent animal on one side, and its own oviduct in a position to be impregnated by a third individual. In the ditches where they abound may often be seen long chains of these animals, in which, with the exception of the two at the extremities, all are alternately fecundated or fecundating."*

When amorous poets sing of Cupid, his quiver and his darts, they use a language which some grave naturalists have believed may be applied literally to describe the loves of some of our commonest snails (Helix aspersa, hortensis, arbustorum). The season urges them to unite, and the wooing pair make their approaches by discharging at intervals several small darts at each other. These darts are shaped something like a bayonet, and made of a horny crystalline substance; they are contained within a cavity—the quiver—on the right side of the neck, from which they are said to be launched when the animals are about two inches distant from each other; and the darts being shot home, the affections are won and a marriage is the result! Such is the story you will find told in almost every popular compilation of natural history, with more or less detail of time and circumstance, sometimes in prose and sometimes in verse; but it has little foundation in fact. The existence of the darts, in some few species of Helix, is certain; while the power of the snail to throw them from its reservoir is imaginary.†

* Brewster's Journ. of Science, Oct. 1829, p. 336; Ann. des Sc. Nat. xxx. 59. Adanson Hist. Nat. du Senégal, Coquill. p. 10.; De Montford Conch. Syst. ii. 264 and 272.—To those curious physiologists who will have a reason for every thing, the following passage, containing a reason for the hermaphroditism of snails, may be acceptable:—"Hujus autem divisionis illa, ut opinor, præcipua ratio est: nempè, cùm id genus animalia omnino pedibus careant, sine quibus nullam esse posse copulam, invita fœmina ad venerem peragendam; itaque ut ambo sint mares, ex aliqua saltem corporis parte, necesse est. Etenim in coitu celebrando solicitatæ fœminæ ferè mares metuunt, et aversantur: ideoque et unguibus et dentibus pleraque animalia fœminas, dum eas subigere cupiunt, sibi arripiunt, omnibusque viribus detinent. Igitur in Cochleis, quibus nec ungues, nec dentes, idonei sunt, ne fœminarum protervitas coitui obstaret, ambo maris œstri participes facti sunt, quò ad copulam jungendam eodem impetu sibi mutuò adcurrant, incantque."—LISTER, *Exer. Anat. de Coch.* 145.

† "If such are ever discharged at each other we have been extremely unfortunate in our observations, for in no one instance could we ever find the

My own observation agrees with what Bradley tells us of these amatorculists:—"The manner of their meeting to couple is well worth observing; in dewy evenings, or after a shower of rain, they crawl upon the grass in a circular manner, making several rounds, till they come near enough to one another to hit their design: I have observed them sometimes make above twenty turns before they could join."* After the union has been dissolved, you may frequently find the dart sticking in the neck of the snails, or merely adhering to the skin by the tenacity of its mucus, for the penetration of the point is very slight; nor do I know what the true use of the dart is, being little pleased with the conjectures that have been offered.

The spawn of the aquatic tribes, whether of the fresh waters or of the sea, is a gelatinous mass, in which the ova are imbedded in a manner similar to that of the Littorina vulgaris.† The jelly seems to have some peculiar qualities, —to be a substance intermediate between albumen and gela-

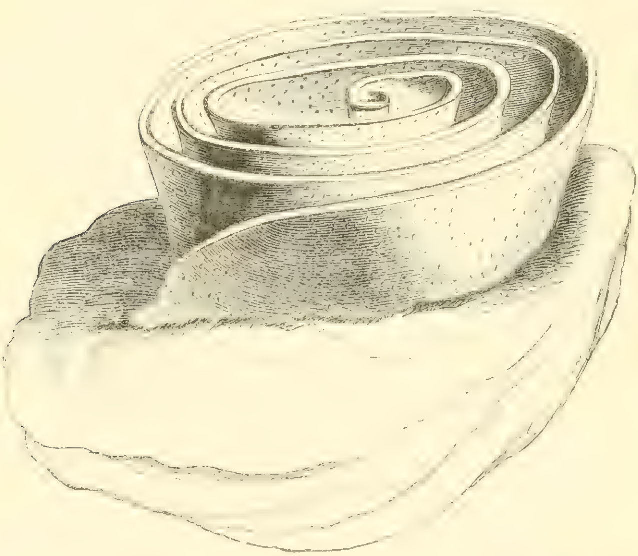
dart penetrated; though at the time the animals are close the point may irritate; but it is neither sufficiently strong nor sharp-pointed to penetrate the tough skin with which these animals are furnished."—MONTAGU, Test. Brit. 410. See also Müller Verm. Fluv. and Ter. ii. pref. xiii., and Draparnaud's Hist. des Mollusq. p. 6, 7.— Blumenbach has figured the dart of the common snail in his Elem. Nat. Hist. trans. pl. 1. fig. 8; and Lister more accurately in the anatomical plate ii. of his Hist. Conchyliorum.

* Phil. Account, p. 127.—The manner of courtship is, however, often less formal; and few can have leisure or patience to watch their tardy advances. I need only refer to Swammerdam's account of them.

† Baker has given a description of the spawn of Limneus putris, which is good enough to be quoted:—"The spawn, when first deposited, appears to the naked eye like a transparent jelly; but if examined by the microscope one sees in it numbers of small and exceedingly pellucid oval bodies, at little distances from one another, inveloped in a gelatinous substance; having each of them towards one of its extremities a very minute dark speck, wherein, if carefully examined by the greatest magnifier, a pulsation may be discerned. This speck will be found to grow larger from day to day and to become a perfect snail, with its shell complete, several days before it bursts through its integuments. When the eggs are about a week old the embryo snail may be discerned in its true shape, turning itself very frequently within the fine fluid in which it lies; and the heart is then a most agreeable and amazing spectacle, shewing itself very distinctly and resembling a little oblong bladder, much less at one end than the other: the pulsation proceeds under the eye with great exactness and regularity, and the systole and the diastole of this vessel are nearly equal to those of the human heart, somewhat more than sixty pulsations being performed in a minute, as I have found by several trials, keeping my finger at the same time on my own pulse, which usually beats one or three strokes more. The heart is large in proportion and may be always seen, until the animal increasing in bulk and becoming consequently more opaque, in some positions it hardly can be perceived; but as the animal frequently turns itself within

tine, distinguished from the latter by its insolubility in water, and by affording no precipitate with solutions containing tannin; and from the former by not coagulating on the application of acids or electricity, and by forming compounds with the alkalies which are not saponaceous. It is sufficiently tenacious to adhere with firmness to the leaves and stones on which it is deposited, and compact enough to retain its form. This is usually oval or linear-oblong,* but sometimes the figures are more artificial. Messrs. Alder and Hancock have figured the spawn of many Nudibranches, which is often laid in coils, modified in character in different species. You have here the representation (Fig. 76) of a

Fig. 76.



characteristic example in the spawn of a large Doris, for which I am indebted to Mr. Cock of Falmouth. I once

the egg a little patience will bring the heart in full view again, and that as long as the embryo continues within the egg. Nay, even after it is hatched, the heart may be discovered for some days through the transparent shell."—*Employm. for the Microscope*, p. 325, 326.

* The eggs of the Ampullaria, an exotic genus of fresh water shells, are in the form of little rounded vesicles, often agreeably coloured with green and clustered in groups upon the stalks of aquatic plants. Rang, *Man.* 195. See the Ray Rep. on Zoology, 1845, p. 120, for a description of the egg capsules of Valvata piscinalis.

found the same modified by the site to which it was attached, so as to have become like a riband fully eight inches in length and $\frac{6}{10}$ths of an inch broad; and this was elegantly wrapped round the lower part of the stem of the Tangle, to which it adhered by one margin only. The riband was of a white colour, and within its substance the ova, in countless numbers, were neatly arranged in regular cross spiral lines.* The spawn of the Eolis papillosa forms an elegant spiral chain of a milk colour and several inches long, twisted upon itself and constricted at regular intervals, so as to resemble a necklace made of bugles. The ova, as in the diœcious phytophagous Mollusca, are very numerous. Mr. C. Darwin calculated those of a Doris native of the shore of the Falkland Islands. "From two to five eggs (each $\frac{3}{1000}$ths of an inch in diameter) were contained in a spherical little case. These were arranged two deep in transverse rows, forming a riband. The riband adhered by its edge to the rock in an oval spire. One, which I found, measured nearly twenty inches in length and half in breadth. By counting how many balls were contained in a tenth of an inch in the row, and how many rows in an equal length of the riband, on the most moderate computation there were six hundred thousand eggs. Yet this Doris was certainly not very common; although I was often searching under the stones I saw only seven individuals."† This is a striking illustration of a fact very general amongst invertebrate animals,—their numbers bear no proportion to the exceeding multitude of their eggs, as if the law given to man to plenish the earth was in them restricted merely to the perpetuation of the species.

The terrestrial genera are greatly less fertile in ova. The Helix pomatia, according to Lister, deposits only about fifteen eggs; and in our common snails they do not exceed from thirty to fifty. In general they are separated from each other, though deposited in little heaps; but a large species of native slug which inhabits cellars has the eggs,

* There is a figure of the spawn of a Doris in Baster, Opusc. Subs. i. tab. x. fig. i. C. D. The spawn of Pleurobranchus is very similar. Audouin and M. Edwards, Litt. de la France, i. 134.

† Voy. Adv. and Beagle, iii. 258.—The ova of Doris tuberculata, "on a moderate computation, cannot be less than fifty thousand."—Alder and Hancock in *Ann. and Mag. N. Hist.* xii. 235. But its young "have myriads of enemies in the small infusoria, which may be noticed with a powerful microscope hovering round them, and ready to devour them the instant weakness or injury prevents their keeping in motion the cilia, which serve both for locomotion and defence. Let them cease to move, a regular attack is made and the animal is soon devoured; and it is interesting to observe several of these scavengers sporting in the empty shell as if in derision at the havoc they have made."—Peach in *Ann. and Mag. N. Hist.* xv. 446.

which are large, strung together like a necklace by a narrow thread. Swammerdam has noticed the peculiarity in other species. "Some snails," he says, "lay their eggs up and down on the ground, others tie them all together like a chain."—The form of the egg is spherical or oval; and their colour is usually bluish-white or milk-white unstained by any markings. The eggs, however, of the Helix bicarinata and H. purpurea are of a beautiful yellow, a colour which also distinguishes those of the Agathinæ indigenous to Africa and its islands.* In size the ova vary as much as do the creatures from which they come: in the common snail (Helix nemoralis) they are not larger than mustard-seed, and their necessary minuteness in such a diminutive Mollusk as Helix pygmæa must render them invisible to our eye; but those of the Bulimus hæmastomus, Lamk. are almost as large as a pigeon's, and with a shell equally hard and calcareous.† The arboreal species of Bulimus which inhabit the Philippines "deposit their eggs in little clusters on the trees, between two leaves which the animal manages to curl up, one upon the other, so as to form a receptacle for their protection; and so far as Mr. Cuming's observations go, they are all soft, like snake's eggs, with the single exception of the B. mindoroensis, in which instance the eggs are calcareous, deposited upon a leaf in parallel rows, each standing perpendicularly on end, attached at the base by a glutinous substance." ‡ The earthborn tribes exhibit less or no artifice, beyond that little which leads them to conceal their fruit in a sort of subterranean nest, or lay them under stones or clods of earth, or hide them in moss or amidst decaying leaves, where they hatch secure from the evil influence of the sun and of the summer's drought.

Being laid, the eggs even of the land Mollusks rapidly acquire an increase of size, for the volume of the entire mass, deposited in the space of from twenty-four to thirty-six hours, almost always exceeds that of the animal even with its shell included. And the external envelope or shell acquires also additional opacity and hardness, which proceeds from the gradual and successive deposition of a great quantity of particles of carbonate of lime over its whole inner

* Ann. des Sc. Nat. xxiv. p. 25, 37.

† See also Encyclop. Method. i. 319. Lister has figured the egg. Hist. Conch. tab. 23, fig. 21.—The egg of Voluta brasiliana has a diameter of seventy millim. while the animal itself has only two hundred.—*Ray Rep. on Zoology, &c.* 1845, p. 119.

‡ L. Reeve in Ann. and Mag. N. Hist. ser. 2, i. 273.—"The tropical Bulimi cement leaves of trees together to form an artificial nest for their large eggs."—Owen's *Lectures*, 308.

surface. These particles, in the genus Helix, have the form of regular rhomboidal crystals, which we know is the primitive form of the crystals of carbonate of lime. The crystals are so large and fine that they may be made exquisite objects for the microscope, and we are, whilst viewing them, wrapped in admiration to conjecture by what subtle process of excretion and chemical affinity the fluid from which they are deposited must have been exhaled and left in a quietness not to disturb the regularity of the deposition on the first minute nucleus. The eggs of all the testaceous (terrestrial) Mollusca, according to M. Turpin, have the exterior envelope hardened in this manner, viz. by the addition of carbonate of lime on its internal surface, but very few of them offers the lime in the state of crystallisation exhibited in the egg of the Helices; but, on the contrary, it is, as in the eggs of birds, and in the bone of vertebrate animals, deposited in grains and confusedly. Such is the inference Turpin draws from an analysis of the ova of the Bulimus hæmastomus and Achatina variegata, among the largest of any Mollusks. The eggs of all the naked snails (Limacidæ) are soft, transparent, and entirely destitute of the calcareous particles or crystals; and it is curious to remark that the eggs of a genus which is intermediate between the shelled and naked tribes, the Cryptella of the Canary Isles, have the same neutral character, for the coat or shell is indeed covered interiorly with numerous crystals, but the crystals are ill-formed, and exhibit the rhomboid figure very imperfectly.*

Buffon has said that all shelled Mollusca are oviparous. This is true, in a physiological sense, when applied even to the whole class;† but there are many exceptions to the axiom if we take the word oviparous in its popular meaning as signifying animals which extrude their young from the body enclosed in an egg. The only classes which in this latter view are unexceptionably oviparous are the Cephalopods, the Pteropods, and Brachiopods. The progeny of the Tunicata are not born until they have passed into the larvated state; and I have instanced a few viviparous species amongst the Bivalves, and the diœcious phytophagous

* Turpin in Ann. des Sc. Nat. xxv. 426, and in Ann. des. Sc. Nat. vi. (1836) 14. Part. Botanique.—The egg of Limax rufus has a calcareous shell according to Laurent. Ann. des Sc. Nat. (1835), iv. 249.

† "*Omne vivum ex ovo*, peut-on dire aujourd'hui avec plus de raison que dans les siècles précédents. Il n'y a plus un animal dont on ne connaisse ou l'appareil sexuel ou quelque moyen de reproduction."—Van Beneden, *Ann. des Sc. Nat.* (1849) xi. 13.

Mollusca. We find also a viviparous species where we should little expect, à priori, to find it, amongst the zoophagous Mollusks that produce concamerated nidi. The Yet (Fig. 29, p. 169), or Cymba neptuni is so; and the shell of the new-born young is an inch long. Adanson found four or five of these in one parent; and he thinks that the mother nurses them in the first months of their infancy, for he had seen several which carried about their five little ones in the folds of the elephantine foot until the shell of them had reached the length of an inch and a half.* The fragile species of Bulimi, with a simple lip to the shell, are mostly viviparous; the Partula, a genus allied to Vertigo, is similarly conditioned; and we find other viviparous hermaphroditical species in the genus Helix itself.

Adanson's anecdote of his "Yet" reminds me of some other species which make seemingly an amiable exception to that cold indifference to their ova and young which characterizes the vast majority of the Mollusca. The ancient naturalists indulge in stories of the Cuttlefish hatching their eggs and guarding their nests with jealous care; and, according to Aristotle, the female is often to be seen resting against the ground and covering the eggs with her body. The Ocythoë or Argonaut nurtures her eggs in her beautiful shell.† Neritina fluviatilis is said to carry its offspring about on its shell; and the N. pulligera has got its name from a similar habit;‡ but the inferences are probably deduced from some accidental occurrence or from misinterpreted observation,§—as has undoubtedly been done in the case of our common Limpet, when it was found, perchance, seated upon some very little individuals of its own species,—oppressing and not brooding on them. The Calyptraea affords a less exceptionable example, for this Gasteropod appears

* Senegal, 48.

† "Mr. Adams regards the Argonaut shell as a nest formed by the female to contain her eggs; if this is correct, it can scarcely be compared to other shells. He regards the shell as similar to the cartilaginous cases which Murices and other zoophagous Mollusca form to contain their eggs; but it has no apparent analogy to those bodies, which are secreted by the oviduct as the eggs are deposited."—J. E. Gray, *Moll. Brit. Mus.* 29. See also Edwards' Eocene Mollusca, 7.

‡ Blumenbach's Nat. Hist. 265.

§ "Grana, quæ dorsum cochleæ frequenter occupant, esse ipsius Neritæ pullos, Rumphius docet; horum ducenta triginta quinque in uno specimine numeravi, ovalia, convexa, extus luteo-albida, intus alba, moleculis referta, corpuscula hæc sæpe absterguntur, remanente in testa circulo ovali albo. Nisi obstaret autoritas exactissimi Rumphii, ovula peregrini animalculi putarem."—Müller, *Verm. Terr. et Fluv.* ii. 196.

literally to sit upon and hatch its eggs. The mother disposes them under her belly, and preserves them, as it were imprisoned, between the foot and the foreign body to which she adheres, her patelloid shell thus serving not only to cover and protect herself, but as a shield to her offspring. The young Calyptraceæ are developed under this kind of maternal roof, and do not quit it until they have strength to attach themselves to the rock, and until their own shell is hard enough to afford protection when so attached. The eggs themselves are ovular corpuscules enclosed, like the zoophagous Mollusks, in membranous elliptical flattened capsules filled with an albuminous matter. The number of capsules varies from six to ten, each enclosing from eight to twelve eggs; and they are all joined together by a pedicle in such a manner as to make up the representation of a sort of cockade.*

Until very recently nothing was deemed, amongst malacologists, more certain than the axiom that no species in the sub-kingdom Mollusca was subject to a metamorphosis,—but now the vivid language of some naturalists might lead you to suppose that they do all of them exhibit, in their progress from quickening to maturity, metamorphoses as striking and marked as those which insects offer to our study. This, however, is not exactly the case. It is admitted that the Mollusca have, indeed, in their embryo condition, or at birth, an appearance and a form very dissimilar to what they have in adolescence and adult age, and hence they may justly be said to metamorphose; but in their developement there are no stages—no arrests of growth, as in insects, but a gradual and imperceptible advance of transformation, which is completed in the very earliest days of life, and before the body has outgrown an almost microscopical minuteness.† "Semper ad eventum festinat."

The discovery of a metamorphosis in the class was first made, I believe, by M. Sars, a distinguished Norwegian naturalist, who has therefore the merit of having inserted the lever, which was to overturn and erase the long unquestioned error. The discovery was made on a species of the order Nudibranches; and it was soon shown to be general in this order by Alder and Hancock, Nordmann, Quatrefages, Löven,‡ Peach,§ and Allman. Van Beneden earlier verified

* Audouin and M. Edwards, Hist. Litt. de la France, i. 133.

† M. A. de Quatrefages has, in an essay just published, pointed out this distinction. "Embryogénie des Tarets" in Ann. des Sc. Nat. (1849) xi. 226.

‡ Ray Reports on Zoology, 1847, p. 430.

§ Ann. and Mag. N. Hist. xv. 445.

Sars' discovery in the Aplysia, the representative of the order Tectibranches ; and it was only at a little later period that it was extended to the Pectinibranchial Gasteropods by Löven, Peach, and Milne-Edwards. Löven has recently been pretty successful in proving that the bivalves undergo a metamorphosis in all respects analogous to that of the Gasteropods.* Hence it seems fair enough to conclude that the class metamorphose ; but the conclusion awaits confirmation by an appeal to one or two orders, and several large families, yet unexamined. It will only apply, under a modified form, to the Tunicata ; and finds the Cephalopods not amenable to any changes.

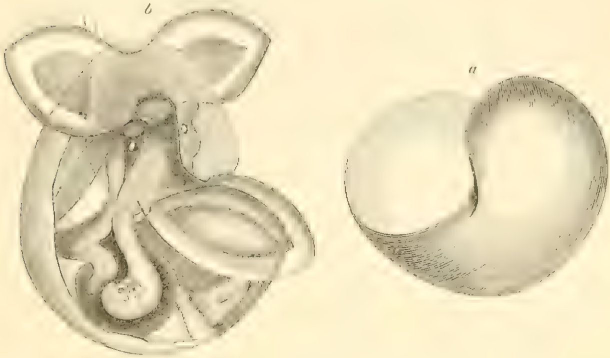
The metamorphosis is very much alike in all the genera in which it has been witnessed. Messrs. Alder and Hancock thus describe its progress in the Nudibranches: — "The spawn of the Nudibranchiate Mollusca is deposited in the shape of a gelatinous band, always arranged in a more or less spiral form, and fastened to corallines and the under sides of stones by one of its edges. The ova are minute and very numerous, amounting in some species to several thousands. Before the period of exclusion, the young may be seen revolving on their own axis by means of vibratile cilia, and on escaping from the egg, they swim about freely in the water by the same means. The larva is extremely minute, and has more the appearance of a rotiferous animalcule than a Mollusk. It is inclosed in a transparent, calcareous, nautiloid shell, with an operculum. Its structure is very simple, showing no signs of the external organs that distinguish the future adult. The principal portion visible outside the shell is composed of two flat discs or lobes, fringed with long cilia, by the motion of which it swims freely through the water. These are often withdrawn into the shell, and the operculum is closed upon them when the animal is at rest. We have not been able to trace the animal further than the first stage of its developement, and are therefore unable to say by what process it assumes the

* Löven's observations were made on Anodonta, Modiola discors, and Kellia rubra.—De Quatrefages thus concludes some researches into the developement of the Teredo :—" Il est bien évident d'après ce qui précède que les Tarets subissent de véritables metamorphoses avant d'atteindre leur forme définitive. Des observations analogues ont été recueillies sur les Anodontes, il y a une douzaine d'années, par MM. Carus, Jacobson et moi-même. En voyant ce fait de produire en quelque sorte aux deux extrémités de la classe des Acéphales, il est, je crois, permis de penser qu'on le retrouvera dans le groupe tout entier."—*Ann. des Sc. Nat.* (1848) ix. 36.—See also a short notice of Mr. Caillaud's observations on Gastrochæna modiolina in Ray Rep. on Zoology, 1847, p. 230.

very different form of the adult state. We have succeeded in bringing out the larvæ of Doris, Tritonia, Melibœa, and Eolis, between all of which there is a very great resemblance."*

On comparing the larva with the adult Mollusk, we find the following differences:—it has a nautiloid shell (Fig. 77, *a*); and in lieu of tentacula, it has two veils, shaped somewhat like ears, and which empower it with rapidity of movement (Fig. 77, *b*). These veils disappear at a later period, and

Fig. 77.



leave no trace of their existence. Destined to feed on soft infusorial animalcules, the larva has as yet none of the complicated oral organs of the adult; and the stomach is situated much further backwards in the body. The branchiæ and the digestive cœca are wanting; while the existence of an operculum necessitates that also of a peculiar muscle to attach and govern it. The eyes, the ears, the liver on the left side, and the anus on the right, are as in the adult.

How long the larva remains in the first stage is still unascertained. Arriving at the second stage, we find it still enclosed in its shell, but the mantle has become detached and covers tightly the mass of the viscera. The foot is so enlarged that it forms a considerable projection beyond the margin of its operculum; and the veils have also grown in size, while the eyes have altered to a violet colour. The head has now two short conical ciliated tentacula; and the little animal swims with surprising quickness.

* Rep. Brit. Assoc. 1844, p. 27. Also Ann. and Mag. N. Hist. xii. 235. Monogr. Brit. Nudibr. Moll. ii. pl. 1, fam. 3.

In the third stage the shell has fallen off, and the general shape is that of the parent; but the veils still remain. In the fourth stage the creature begins to crawl in the Gasteropod fashion, and the branchiæ and cœca begin to sprout. There are now also visible pulsations in the heart; and the mouth arms itself with jaws and with a spinous tongue. Another stage is marked by the fall of the veils, and by the budding forth of the anterior tentacula, as well as of the branchiæ; and the full evolution of these organs completes the metamorphosis, and entitles the animal to the privileges of maturity.*

In all Gasteropods whose developement in the egg Milne-Edwards has had the opportunity of tracing, the embryo presents, in its first stages, the same characters; and it is only in the latter period of its metamorphosis, that the young animal acquires those peculiarities of structure upon which the class of which it is a member is subdivided into families and genera. Thus, up to a certain age, the larvæ of the Vermetus, Cerithium, Pleurobranchus, Doris, and of the Aplysia, have the same manner of conformation; and it was only when they became recognizable as Gasteropod Mollusca that some differences of a secondary order were observable in their structure. Milne-Edwards' researches have likewise satisfied him that in all Mollusca the series of the organic developements is not the same as in the vertebrated animals; and he is convinced of the existence of a certain relation between the degree of importance which the leading systems of the economy offer, considered under a zoological view, and the chronological order of their appearance in the growing organism. All the phenomena of their genesis, too, are opposed to the opinion of those physiologists, who maintain that the embryo of the superior animals, even that of man himself, offers in succession modes of organization analogous to the permanent condition of each of the principal inferior types of the animal kingdom, so that the Mollusk, for example, is the permanent representation of one of the transition forms of the young mammal in the course of its formation. It is far otherwise. The Mollusk, from its origin, is constituted on a model which is peculiar to it; and the first characters of animality visible in the embryo of the mammal are, on the contrary, those by virtue of which the mammal belongs to the great division of Vertebrates. The differences are, therefore, primordial, and do not justify the hypothesis alluded to.†

* Nordmann in Ann. des Sc. Nat. (1846) v. 155 and 158.

† Ann. des Sc. Nat. (1845). iii. 138.

LETTER XXI.

ON THE AGE OF THE MOLLUSCA, THEIR RENEWAL OF LOST ORGANS, AND THEIR DISEASES.

The young of the Mollusca, immediately on their exclusion from the egg, or from their brief span of a larvated life, enter into all the habits and instincts of their parents. Their growth, like that of the young of animals in general, is rapid; and the secretion of the shell proceeds at an equal pace, the proportion of its earthy constituents being at the same time increased in most of them, that its strength and density may have a certain correspondency with the growing strength and bulk of the inmate. How long the time may be which the Mollusk requires to finish its house is yet unknown, or only known in a very few terrestrial species. A Helix pomatia born 15th of September, 1825, grew progressively until checked by the approach of winter on 26th of November. It resumed its growth 1st of April, 1826, and completed the shell on the 31st of July, or about six weeks within the year.* I have been led to believe that some of our Helices require two years for this purpose,—that is to say two summers; but probably the time is influenced both by the temperature and moisture of the seasons. The oyster is said to require four years to attain its fullest size. Steno and others have asserted that we may measure the time which a Mollusk occupies in completing its structure by counting the number of layers in the bivalvular shells, and the number of whorls in the turbinated univalves, a layer or a whorl being the work of one year, but I am certain that Müller is right in pronouncing the test to be altogether fallacious. It would give a slowness of growth to the oyster, which we know to be contrary to fact; and with reference to the univalves it should be remembered that at least two whorls are completed previous to birth; and I know that the remainder may be completed, in our common snails, in the course of a single summer. And in those marine tribes which, from the depth of their localities, suffer no alternations of temperature, and con-

* Pfeiffer, Bull. des Sc. Nat. Jan. 1829, p. 145.

tinue actively at work throughout the year, it is reasonable to infer even a quicker growth. Hence you may reject as worthless all calculations of the age of Mollusca founded on the basis in question; and when fifty or sixty years are stated to be a moderate computation of the average life of the Unio margaritiferus,* and thirty years of adolescence are assigned to the Tridacna gigas, I do not hesitate to state my belief that the calculations are greatly exaggerated, although an eminent geologist, proceeding on the latter statement as on a fact, has thence deduced an argument for the slow growth of coral, and the slow rate of increase of calcareous reefs.† The rapid renewal of exhausted beds of oysters, and the annual harvests yielded in many places by cockles, prove more certainly the rapid attainment of maturity in the class. Mussels of small size, and probably of only a few weeks' age, when deposited in a favourable site, reach their maximum size within the year; and, according to the fishermen on our shore, this is also the case with the Limpet. The fishermen at Marseilles told Cuvier that the Aplysia attains its full size of about four inches in length in one or two months.‡ Having attained maturity I know of no data which inform us to what length of days the life of the Mollusk is prolonged. Of land snails, Swammerdam says:—"The period of their natural lives cannot be certainly determined, but I am inclined to think they live to a very great age, which may probably be conjectured from the slow increase of their shell." You may arrive at the same conclusion on the surer ground of their peculiar organization, which necessitates a certain degree of sluggishness in the action of every organ, and a low insensate nature, that, as in reptiles, is favourable to the prolonged continuance of life.

It is this low organization which enables them to recover from injuries that would annihilate more lively entities, and which endows them with the property of renewing organs lopt off by accident or an enemy. Snails (Helix) will live six or seven days under water; and if bruised, and taken from their shell, they will still live four days provided they are put into water. Müller froze some living specimens of Physa hypnorum by congealing the water in which they were, but on thawing the water the snails began to move again as usual.§ Still more marvellous instances are on

* Maton's Life of Linnæus, &c., p. 93.

† Lyell's Geology, ii. 287.

‡ Mem. ix. 11.

§ "Joly has observed with respect to certain Mollusca (Paludina vivipara, Lam., and Anodonta cygnea, Lam.) that they may be frozen up in ice without being killed. Some of the Paludinæ even produced young

record. M. de Quatrefages pressed specimens of an Eolis between the compressor until the skin was ruptured and the body, nearly emptied of its sarcode, was flattened almost to a membrane; yet on being replaced in sea-water these individuals recovered perfectly.* And of the Tunicata, we are told that "not unfrequently we find Salpæ making their way through the waters deprived of their nuclei by birds or fishes, retaining their vitality for a considerable time, and exercising their muscular powers when the organs of digestion, circulation, and reproduction have been torn away." †

The singular power the Mollusca have of reproducing organs which have been amputated was first determined by the Abbé Spallanzani, who too often experimented without a definite object in view, for the sake merely of satisfying a cruel curiosity as to the result. He took snails (Helix pomatia, nemoralis, and lucorum), and cut away the tentacula either in part or wholly, and they were renewed in about two months' time, perfect in all respects even to the restoration of the eyes at their tips, with all its humours and coats in their original integrity. "The snail," says Spallanzani, "makes the same use of the new horns as it did of the old, whether by protruding them from the head, extending, contracting, or concealing them, or by displaying their acute and lively sensibility; so that on the most gentle touch, they are suddenly withdrawn and put in safety."‡ If the experiment is carried further, and the half or the whole head amputated, the regeneration of the parts is equally complete, a longer time being allowed for the redintegration; and you cannot reflect on this fact without wonder, for in the head of this creature are placed its organs of sense, the eye, the ear, and the feelers; the brain, the centre of its nervous system; the mouth and its various appendages, and a large mass of muscles; yet all these organs grow again to such perfection that they cannot be distinguished from the original formations! All the circumstances requisite for the success of the experiment are not well known. If adroitly conducted success in general follows; but under apparently the same circumstances the

shortly after they had been frozen."—*Ray Reports on Zoology*, 1847, p. 216.

* Ann. des Sc. Nat. (1843) xix. 278 and 311.

† Forbes and Hanley, Brit. Mollusca, i. 47.

‡ Tracts on the Nat. Hist. of Animals and Vegetables, translated by J. G. Dalyell, ii. 228. I refer to this volume for a very complete history of Animal Reproductions.

experiment often fails, and the mutilated animal may be kept years in vain expectation of witnessing "this admirable reproduction." A sufficient degree of heat is essential to the success. Temperate is not enough; and the heat must be at least 61°.

The experiments of Spallanzani, made principally during the spring and summer of 1766, raised curiosity to a high pitch, and led to a very general decapitation of the snail race. The results were confirmed by M. Bonnet, M. Tissot, Father Barletti, H. Roos, M. Lavoisier, Turgot, Tenon, Herissant, Müller, Scarella, Schœffer, Abbé Troilo, Senebier, and by Signor Caldani, Girardi, and Pratalongo; and their accuracy was denied by M. Wartel, Father Cotté, M. Valmont de Bomare, Argenville, Schrœter, Murray, Adanson, and Presciani. Adanson's opinion was given with characteristic confidence: "I have," he said, "as every one has had, reproductions, even very immediate ones, of horns, heads, lips, and other parts; but these were reproductions of parts that had not been entirely cut off: for all the heads, I say, the real heads, all the horns, all the jaws, and the other parts which have been completely cut away, and only a quarter of a line from the origin, never exhibited any kind of reproduction, far less a complete regeneration. Let us be strict, and investigate the truth. All who have mutilated snails, and first Sig. Spallanzani, have certainly been deceived. They have thought the head was severed when the cap only has been cut off: they have believed that they separated or eradicated the horns and jaws, while the origin always remained; whence it is not wonderful if reproductions ensued. These, you will candidly admit, are not reproductions, or rather regenerations, such as you, Trembley and Reaumur, had seen in fresh-water worms, the polypus, the claws of lobsters.—How many well-credited operations have deceived persons, less familiar than us, with similar operations and the anatomy of shelled animals. They have thought that they had completely cut off so many heads, horns, and mouths, beyond the origin, which in every journal and periodical paper, they have so liberally regenerated. I am well aware of our deficiency in most nice experiments; and, notwithstanding my great experience, I may almost presume to say, dexterity in the anatomy of the smallest animals, I always distrust myself. For this reason I have repeated the same experiments an hundred and an hundred times before hazarding the results before the public." But neither this strong denial, nor other counter-evidence, can rebut the positive experiments of Spallanzani; and the

very boldest of his statements,—the renewal of the entire head,—has been even established by naturalists in the fullest manner, for it is not true, as Bosc and others would have us to believe, that "the animal infallibly dies when the first ganglion, which essentially constitutes the head, has been taken away." * In 1808, M. Tarenne decapitated many snails, and proved, by careful dissection, that the amputated portion contained not only the tentacula, the jaw, and the upper lip, but the brain likewise, and the anterior part of the foot, yet these maimed individuals reproduced the head complete at the end of one year or more. The new head only differs from the old by having a paler and smoother skin; and sometimes a sort of furrow marked its junction with the trunk.†

It is not, as Spallanzani ascertained, every kind of snail (Helix), which possesses the power in question; nor is the power limited to that family of Mollusks. From a very early date in the history of animals, it has been affirmed that the Cuttle-fish could renew their amputated limbs; and the snail of the beautiful Harp-shells (Harpa) reproduces its foot. This member is so disproportionably large that it cannot be drawn within the shell in extraordinary circumstances, so that when attacked by an enemy the Mollusk, by pressing the foot firmly against the sharp lip of the shell, voluntarily cuts away the hinder portion, and thus secures its safety by the loss of its limb.‡ In two or three species of pectinibranchial zoophagous Mollusca Madame Power proved the reproductive agency in them by direct experiment. She lopt off the tentaculum with the eye from a Triton nodiferum, and at the end of twenty days a new tentaculum had grown six lines in length,—"that which had been cut off measured fourteen lines." A Murex trunculus reproduced the head and tentacula, and the operculum, which had been purposely torn away; and a Conus its tentacula and respiratory siphon. § The foot of the Mussel (Mytilus edulis) being cut off will be renewed.

The diseases of the Mollusca are scarcely known; and all the accurate information we possess is limited to their parasites. Of terrestrial Mollusca, Reaumur has described in detail a sort of mite which infests the Helicidæ or Snails of France. It is found in numbers on them in dry weather, but rarely in rainy seasons, for the viscid secretion of the snail being then abundant seems to destroy the parasites.

* Griffith's Cuvier, part xxxix. p. 329. Bosc. Vers. i. 89.

† Bowdich's Man. of Conchology, i. 75.

‡ Rang's Manual, p. 211.

§ Charlesworth's Mag. N. Hist. ii. 64.

Having collected some snails in a wet season no mites could be discovered on them; but placing them in jars to exclude the moisture, their acaridan pests were seen upon them after the lapse of some time, varying from five or six days to three weeks. Reaumur has counted upwards of twenty mites on the same snail; and he tells us they are rarely seen at rest, but are almost always creeping about, which they do with extreme quickness. They are usually noticed near the collar of the snail on the exterior of the body, but Reaumur believes they are there by accident, and that their natural place is within the intestine. The mites, he says, are continually on the watch to enter the vent whenever the snail has occasion to open this aperture; and it is no sooner opened than they rush in and walk quickly up the canal. The reason that we find them on the surface is this,—they are pushed out of the intestine along with the excrements, and they must remain on the surface until a favourable opportunity presents itself for their re-entrance. In Cyclostoma elegans, Reaumur found acari in the very middle of the intestinal canal.*

The Rev. Leonard Jenyns has found the same mite (Philodromus limacum) on some of our English slugs (Limax variegatus and Arion empiricorum); and his observations respecting it agree generally with those of Reaumur. But he differs from the great French naturalist in believing that the natural habitat of the mite is the pulmonary cavity, and not the intestine. "I am inclined to think," he writes, "that this cavity is its principal residence, whence it only comes forth occasionally to ramble upon the surface of the body. In one instance, I confined in a close box a slug which, to all appearance, was free from parasites. On opening the box a day or two afterwards, I observed very many crawling about the slug externally, all of which would seem to have proceeded from the pulmonary cavity. On another occasion I observed these insects running in and out of this cavity at pleasure; and some which I saw retire into it never re-appeared, although I watched the slug narrowly for a considerable time. It is remarkable, as Dr. Shaw observes, that the slug appears to suffer no particular inconvenience from these parasites, and even allows them to run in and out of the lateral orifice without betraying the slightest symptoms of irritation." † In England the mite seems to have been found on slugs only; in France it infests slugs and

* Hist. de l'Acad. Roy. des Sc. for 1710, p. 414.

† Loudon's Mag. Nat. Hist. iv. 539.

snails indifferently;* but in Scotland I have never seen it on either tribe—enjoying there a joke-provoking immunity. —Two or three different mites are born to plague even the fresh-water mussels, by crawling with their spinous feet over the cloak of the animal, or hiding between the layers of its delicate gills. Hydrachna concharum of M. Bäer, which may be identical with the Limnocharis anodontæ of Pfeiffer, and the Trombidium notatum of Rathke, thus fret the Unio pictorum and the Anodontæ.† These mites have not yet been discovered in this country.

The lacustrine Gasteropods are greatly vexed with the parasitism of a worm that has been loosely referred to the genus Gordius (G. inquilinus, Müll.), and which Draparnaud erroneously identifies with the Nais vermicularis.—Müller says that the worm resembles in every respect the tentaculum of a Planorbis.‡ It attaches itself to any exposed part of the skin, but prefers a station between the collar and the neck of the snail, where several may be noticed with one end fixed in the flesh, while the other is ever moving with a sort of painful twisting and twining motion—painful because it reminds one of the worm that never dieth. The ill they occasion is of uncertain nature; and probably there are more than one species, for it is not likely that the parasite of the fluviatile Mollusca of Europe is identical with that of those of the New World. After describing the Physa heterostropha of the United States, Dr. Gould says: "On looking carefully about the neck of the animal of this shell, we find him beset with numerous little things looking like short, minute, white lines, which are, in truth, little parasites (Gordius inquilinus, Müll.), attached like leeches, and which derive their nourishment from the fluids of the animal, without his having the power to dislodge them."§

The leech-like form of this parasite reminds me of another which you may occasionally find in the shells of Bivalves, lurking between the branchial leaflets. This is the Hirudo grossa of Müller, who found it in the Artemis exoleta. I have found it frequently in Cyprina islandica, and once in Cardium echinatum; and although I could not detect a consumption in the fish, yet from the character and relationship

* Loudon's Mag. Nat. Hist. v. 697.

† Bull. des Sc. Nat. Fev. 1829, p. 295.

‡ Verm. Terr. et Fluv. Hist. ii. 33.—Draparnaud mistook the worms for a kind of trachea, whose function it was to separate the air from the surrounding water. *Hist. des Mollusques*, 49.

§ Invert. of Massachusetts, 213.

of the Leech, we are warranted to bring in a verdict against it of conspiring the death of the animal that harboureth it, by sucking out its vital juices.

The preceding are external parasites: a more numerous host infest the viscera and intestines, but I intend to pass them over slightly, for they either do not influence the health and habits of the Mollusks they live and feed upon, or that influence has been unmarked.—Dujardin mentions two infusorial animalcules (Trichomonas limacis and Albertia vermiculus), whose habitat is the intestines of the slugs.* The lacustrine pulmonated Mollusca are more profusely verminous. More than one species of Distoma has been found in their viscera; and, to judge from analogy, we should suppose that the infected organs must suffer softening and disorganization. M. Bäer has also found a Filaria in the abdomen of Limneus stagnalis; and in many Mollusca of the same family he has met with a worm allied to the Naides living in the respiratory cavity, or hanging like little tufts of thread from the sides of the abdomen, whence he has named it Chœtogaster.† Besides these a kind of animalcules named Cercariæ find an appropriate nidus for their evolutions in the body of the lacustrine snails; and the curious transmutations of form they undergo in the interior of the Mollusk, and in the circumfluent water, afford one of the most striking illustrations of Steenstrup's theory of alternating generations. ‡

The parasites of the fresh-water bivalves have furnished M. Bäer with subjects for a copious essay.§ One of them (Aspidogaster conchicola) lives in the pericardium of Unio pictorum, and of several Anodontæ; another worm was detected within the auricle of the heart swimming in the blood; and the species (Distoma duplicatum) to which this individual belonged swarmed populous in every part and viscus of the body of Anodonta ventricosa. Another parasite named Bucephalus polymorphus, from its likeness to an ox's head and its multiformity, breeds and multiplies in the liver and interior of these devoted mussels, which thus may

* Hist. Nat. des Infusoires, 300 and 654.

† "La cavité respiratoire et le rein du Limneus stagnalis ont fourni un autre entozaire nouveau, rentrant, par son organisation, dans la classe des Annélides, et voisin des Naïdes. Les paquets de soies que ce ver porte par paires, sur les côtes de la surface abdominale, lui ont fait donner le nom de Chætogaster. Il s'est retrouvé dans le Planorbis corneus et dans beaucoup d'autres Mollusques d'eau douce. On les rencontre aussi à l'état libre dans les eaux habitées par ces Mollusques."

‡ See Agassiz and Gould's Prin. of Zoology, i. 130.

§ Bull. des Sc. Nat. (Fev. 1829) xvi. 292—297.

be said to have something in common with royalty of the olden date,

> "Upon whose spirit depend and rest
> The lives of many."

The parasites of the marine bivalves, and of the marine Mollusca in general, have been scarcely indicated,* if we except an entozoon (Vertumnus tethydicola) that sucks to atrophy the beautiful Tethys,† and some that infest the Cephalopods. Delle Chiaie enumerates an Ascaris, a Filaria, a Scolex, a Cysticercus, a Monostoma, a Distoma, a Bothriocephalus, and a Dibothriorhyncus amongst the parasites of the latter class;‡ and a peculiar species is devoted to the Argonaute.§ One of the most wonderful entozoa hitherto described is the leech-like worm, named by Cuvier Hecatostoma or Hecatacotyles, because of its having a hundred cups and upwards for attaching itself to its peculiar victim—the Octopus granulatus, one of the Cephalopods of the Mediterranean. This parasite "lives in the abdominal cavity, or even in the substance of the flesh of the polypus, the only animal which surpasses it in the number of cups with which it is furnished. M. Cuvier remarks how favourable this circumstance is to the metaphysicians who amuse themselves with composing the intestinal worms all of a piece with the elements furnished by the body of the animals which they inhabit. Here we have the body of a polypus, which has for its parasite a worm, so like the arm of a polypus, that the illusion cannot be greater. Of the two polypi which he produced before the Academy, there was one in which the Hexacotyles was attached to one of the arms, which it had even nearly destroyed, and which it seems in such a degree to replace, that at first sight it might be taken for the arm itself. 'Let it be judged,' said M. Cuvier, 'how many theories might be founded on such an extraordinary resemblance. Never has the imagination been exercised on so curious a subject.'"|| I take my leave of it in the

* In his Entozoorum Synopsis, Berolini, 1819, Rudolphi does not mention a single species parasitical on these Mollusca.

† "The characteristic Nudibranc of the Mediterranean, a giant among its tribe, Tethys leporina, was only met with once, swimming foot up on the surface of the sea in the Gulf of Smyrna in an exhausted state, its sides being invested by that extraordinary parasite the Vertumnus tethydicola." E. Forbes in *Report Brit. Assoc.* 1843, p. 133.

‡ Anim. s. Vert. Nap. iv. 61: 200, 201.

§ Tricocephalus acetabularis. D. Chiaie, lib. cit. ii. 225.

|| Edinb. New Phil. Journ. Jan. 1830, p. 102. Edinb. Journ. of Science, i. 219.

words of a favourite author: "Surely as Samson at his marriage propounded a riddle to his companions to try their wits thereon; so God offereth such enigmas in nature, partly that men may make use of their admiring as well as of their understanding; partly that philosophers may be taught their distance betwixt themselves, who are but the lovers, and God, who is the giver of wisdom."

⁂ "The sea is His, and He made it."—PSALMIST.

"Verily, for mine own part, the more I looke into Nature's workes, the sooner am I induced to beleeve of her even those things that seem incredible."—PLINY.

"Quapropter, quæso, ne nostra legentes, quoniam ex his spernunt multa, etiam relata fastidio damnent, quum in contemplatione Naturæ nihil possit videri supervacuum."—PLINIUS.

LETTER XXII.

ON THE STRUCTURE AND FORMATION OF SHELLS.

In each of the great divisions of the animal kingdom recognised by zoologists, there is a slightly organised part which, because of its more solid structure, seems intended to protect the vital organs from injury, and to afford points of attachment to the muscles that move the body. In the vertebrated and annulose sub-kingdoms this part or skeleton consists of many pieces articulated by plain sutures or by moveable joints, and those destined to be the fulcra of the muscles of locomotion are placed in pairs on the sides; but while the skeleton of the vertebrates is interior and clothed with the muscles, that of the annulose animals is a mere hardening of the skin, and, in many instances, is shed and replaced by a new one, formed under the older, more than once during the insect's or worm's progress to maturity. The analogous part in the Mollusca resembles the skin also in being commonly exterior in its position. It is either mucous or coriaceous in texture, or oftener solid and calcareous, consisting of one or two unjointed pieces; but, unlike the skin of the Annulosa, it is not deciduous nor divided into annular segments, and has no closer connexion with the soft parts underneath than what is given through one or two muscles that connect the body with it at one or two points only, yet in such a way that their union during life is indissoluble. The skeleton of the vertebrates is, in fact, an organized portion of the body, penetrated with blood-vessels and absorbents, and, like other organized parts, ever undergoing change; but the shell of the Molluscans, although the result of life and organic change, becomes extravascular, so that when once formed it is incapable of being altered by any power inherent in itself. There is this further difference between the skeleton and the shell:—the former is most important in its relations to the function of locomotion, the latter in its use as a covering and shield,* for you will

* M. Robineau-Desvoidy thinks the shell of the Mollusca the analogue of the vertebral apparatus in higher organisms, but his speculations are quite unintelligible to me. The reader will find them in the Edinb. Journ. Nat. and Geogr. Sc. ii. 222, &c.

remember that the central foot, the principal organ of progression in the Mollusca, has either no connection with the shell or an indirect and remote one. Hence we find that when the shell is too small to contain and shelter the entire body it is placed over the heart and respiratory organs, to protect from hurt those, beyond question, most essential to the animal's existence.

Such a shell, however, is not the exclusive possession of the Mollusca. I do not mean to compare with it the testaceous covering of the acorn-shells or of the barnacles (Cirrhopoda), for the differences between them in their composition or combination of parts are so great as to render their distinction easy; but there is a genus of crustaceous insects (Cypris) whose covering very exactly resembles the shell of a minute bivalved Mollusk;* and without a knowledge of the inhabitants it must be difficult, if not impracticable, to distinguish the calcareous case of some marine worms from the tubular shells of certain Gasteropods. The sameness is so near that the best naturalists misarranged the latter until the animals of them were discovered; and I may just remind you that the microscopical chambered shells, long believed to be the productions of Cephalopods of commensurate diminutiveness, are now more justly considered to belong some of them to the Annelides, and others of them to much inferior organisms.† To establish a line of demarcation between these productions and the shells of the Mollusca is, perhaps, important in a geological view, but I am not aware of any that can be in every case made apparent. The points in the interior of the shell on which the muscles of the Mollusca are inserted receive a mark or impression from them which is ever afterwards retained, and when such marks are observed, the conclusion of the shell being a Mollusk's is very certain, for no Annelide is fixed within its tube, but resides within at liberty to leave it on an emergency, and hence no constant marks on the parietes are ever made. But these marks, even when existing, may be too faint to be always perceived, or the smallness of the shell may present an insurmountable barrier to the search of the test; and in this dilemma I know of no other that you can unhesitatingly depend upon.

* "The great affinity that the coverings, or shells, of some of this class of insects bear to the testacea tribe, has in all probability caused many to have been considered as small species of Mytilus, or the fry of larger; for many such Monoculi are capable of shutting their valves entirely, and inclosing every part of the animal; in which state they always are when dead, so that it is no easy matter to discriminate."—*Montagu Test. Brit.* 174.

† Dujardin, Hist. Nat. des Infusories, p. 240—45.

The shell of the Mollusca, under every modification of form, consists of carbonate of lime and animal matter in variable proportions; but "the two are not uniformly diffused through the shell as some have supposed, but are separate elements, each having its own place." Since the publication of the experiments of Reaumur, in 1709, the general opinion with conchologists has been that the lime and mucilaginous fluid was excreted solely from a series of glands seated in the collar or margin of the mantle of the animal, and deposited, by the same part, on the rim of the shell, by which means it was enlarged in the particular form ordained to characterise its species. There was first exuded a line or layer of mucous fluid which, hardening by exposure, became the skin or periostracum of the future shell; underneath this there was then laid a layer of calcareous matter which made itself solid by aggregation or a process of crystallisation, and within this another layer and another, until the requisite degree of thickness was attained. The whole of the material was derived from the glands in the collar, and by the collar only was that material added, particle by particle, to the edges of the shell, and spread along its interior,—the latter effected as the animal successively withdrew far within its cell and again protruded itself. Thus the shell was an excretion, and its solid state being the result of a mechanical condensation, it was consequently an inorganic structure.

There were, however, some opponents to this theory. Herissant, the contemporary of Reaumur, maintained that shell has an organic structure, and that it grows by interstitial deposit in the manner of bone; and Adanson appears to have held the same opinion. If, he says, we consider the shells to be the bone of Mollusks, we must look upon the membrane which covers the greater part of them to be their periosteum; and, in fact, this membrane performs the same function, since it contributes both to the shell's preservation and growth.* So, also, Bradley tells us that "Shells have a kind of vegative growth, and have also vessels of communication with the animal they contain, so that it seems as if the juices of the one were necessary for the support of the other." † Bradley, probably, borrowed his belief from Lister;‡ but the celebrated Poli held the same, maintain-

* Hist. Nat. du Senegal, xliv.

† Phil. Account, 51.

‡ "Per hanc insuper fasciam ipsa testa nutrimentum suum assumat, necesse est; quod inter eam ipsumque animal nulla alia communicatio detur."—*Exer. Anat. de Cochleis,* 18.

ing that bloodvessels passed through the adductor muscles of the bivalves to gain access to the interior of their valves. Cuvier and Blumenbach favour the same opinion, because "the oyster and muscle adhere to the shell, not only by their muscles, but by the whole border of their cloak;" and because "the oyster has always between the two last strata of the convex valve a considerable vacuity, which is filled with a fetid acrid liquor, and which communicates with the interior of the body by a particular aperture. "How," asks Cuvier, "is this vacuity produced? and, above all, how is it removed upon the formation of each new stratum, if the arterial and absorbent vessels do not penetrate into the centre of the strata, to regulate its position, and to remove from time to time the particles of the shell?"* The Rev. Dr. Fleming considered the vitality of shell to be demonstrated from the changes which it undergoes when detached: the plates of animal matter harden; the epidermis dries, cracks, and falls off; and in many cases the colours fade, or disappear. And what but vitality could have prevented these changes previously? The shells of the most delicate of the Helicidæ, which we must handle softly if we wish to have them unbroken, preserve their vivid colours, their pellucidity, and their integrity as long as the snail is living, under whatever influences they are exposed; but no sooner have the shell and snail become separate, than the colour of the shell decays, its transparency becomes dimmed, the epidermis shrivels or exfoliates, and the texture whitens and is rendered more friable. It is the presence of life in the shell that prevents this sad change,—a low degree of life that, as John Hunter said, might exist in animal substances devoid of apparent organization and internal motion, and wherein the power of preservation was simply required.

The opposite opinion prevailed, and shell was all but unanimously reckoned an inorganic structure† until within these few years, when its organism was amply proved by

* Comp. Anatomy, i. 119. Trans. The cavity itself is difficult to find, and escaped my observation in some attempts made to discover it; but I am informed, by a very skilful anatomist, that it is to be found on the anterior part of the shell, at the edge. The communication between it and the body of the fish must be exceedingly minute, perhaps impervious, for no oyster-eating acquaintance of mine has any knowledge of the fetid fluid.

† "The shells themselves are absolutely deprived of vitality, permeated by no vessels, and as incapable of expansion by any internal power as the rocks to which they are not uncommonly attached."—Jones' *Anim. Kingdom*, 385.

the interesting researches of Mr. Bowerbank and Dr. Carpenter.

After a careful microscopical examination of many species in various families of Mollusca, Mr. Bowerbank concludes that the shell is highly organized. The shell of the pectinibranchial and pulmonated Mollusks consists, when perfected, of three distinct strata uniform in the nature of their structure, but alternating in the mode of disposition of their calcareous matter. "Each stratum is formed of innumerable plates composed of elongated, prismatic, cellular structure; each plate consisting of a single series of cells parallel to each other. These plates of cellular structure are disposed alternately in contrary directions, so that each series of cells intersects the one beneath it at nearly right angles, and the whole of them are so disposed that the axes of the cells form angles of about twenty-two degrees with the upper and under surfaces of the shell." "The planes of these plates of prismatic cellular structure, are always either as nearly as possible parallel or at right angles to the lines of growth, and the mode of arrangement is invariable in each separate stratum, and always opposed to that of the stratum either above or below it; so that if the plates of cells in the central stratum be parallel to the lines of growth in the shell, those of the outer and inner strata are at right angles to them. When we view the stratum of plates of prismatic cells, which are disposed at right angles to those I have just described, or view them in an edgewise and endwise direction, they present an appearance remarkably different from that which we have previously described. In this case the whole of the stratum seems to be composed of a series of basaltiform columns, each column having the appearance of being formed of a series of single cells regularly piled upon each other. This arises from the line of fracture passing in a direction about equally oblique to the planes of the whole of the plates of prismatic cells. From this description of the alternating mode of arrangement of the plates of cells, it will be obvious that if, on examining a shell, we find a section parallel to the lines of growth, with the plates of the central stratum agreeing in their direction with those lines, while those of the outer and inner ones are at right angles to them, we shall find the apparent direction of the plates exactly the reverse in each stratum if we view a second section of the same shell at right angles to the lines of growth. These modes of arrangement of the tissues are invariable in the same species and genus, as far as I have had an opportunity of judging; and it is somewhat

remarkable, that of the eight genera examined, four assumed one mode of arrangement and four the other. Thus, upon viewing sections parallel to the lines of growth of the shells, I found that in Cypræa, Cassis, Ampullaria, and Bulinus, the plates of the outer and inner stratum were parallel to the lines of growth, while those of the central one were at right angles to them. On the contrary, in Conus, Pyrula, Oliva, and Voluta, the plates of the outer and inner stratum were at right angles to the lines of growth, and those of the central stratum parallel to them. And it is worthy of remark, that the porcellanous shells do not agree in the mode of arrangement of their tissues, as we find Cypræa opposed to Conus, Oliva, and Voluta, and agreeing with Cassis, Ampullaria, and Bulinus."

A considerable deviation from this structure is met with in the shells of the Mollusca referred by Milne-Edwards to his order Opistobranches. These Mollusks approximate in anatomical character to the bivalve class, and Mr. Bowerbank has ascertained that the same inclination appears in the structure of the shell, for this, in the arrangement of the cells and other tissues, approaches nearly to the majority of bivalves. In the univalve shells in question, of which Haliotis may be assumed to be the type, there is no oblique disposition of prismatic cells, but a regular basaltiform columnar arrangement of cells, whose lines of direction are at right angles to the outer and inner surfaces of the shell. Neither is the shell composed of three strata, but of several layers, consisting of a series of membranes (whose cells are filled with calcareous matter) adhering to each other, and having their planes parallel to the surface. These layers are likewise permeated with tortuous canals, analogous to the Haversian canals in bone. Like the Haversian canals in the bones of the higher classes of animals, they anastomose with each other, and especially in Ostrea; "their courses are equally tortuous and irregular, and their parietes are both lined with a mucous or gelatinous coat. It is true, the Haversian canals in the bones of man are on an average 1-500th of an inch in diameter, while those of shells are 1-5,000th or 1-6,000th of an inch; but their diminutive size in the shell is not out of proportion when we consider the difference in the size of the animals. There is another tissue apparent in the structure of this shell, which draws still closer the alliance which exists between it and bone. If we examine the membranous remains by transmitted light, with a linear power of 1,000, we find embedded in the spaces intervening between the sections of the canals an abundance of the

remains of exceedingly minute vessels or elongated cavities, which measured 1-20,000th of an inch in diameter, and which are either the remains of minute inter-cellular vessels, or of cavities analogous to the so-called corpuscular bodies of true bone; and here the discrepancy in the size of the organs is not so great, as one of the smallest of the bone-corpuscles measured 1-9346th of an inch, while one of the calcigerous tubes radiating from it was 1-15,456th of an inch in diameter."

Bivalved shells exhibit too great a variety in structure to be described summarily in a paragraph, but in the greater number the shell is lamellated, the lamellæ being formed of fleshy membranes whose secreting cells are filled and hardened to stone by the deposition within them of carbonate of lime. The cells may be distinctly columnar and placed at right angles to the surface, or they may be less definite in form and laid parallel with it; and either structure may prevail throughout the thickness of the shell, as in Pinna, or may be combined to form it, as in Modiola. In the genus Ostrea, the structure consists of alternating layers of fleshy membrane and cellular structure, "which are produced in succession from the inner surface of the shell." But whatever may be the modification of structure it is, in all bivalves, permeated with Haversian canals, and with an interstitial vascular system more or less developed. There are, according to Mr. Bowerbank, other vessels in the apparently stony shell. "The vessels which I have hitherto described," he says, "are not the only ones which exist in the shells of molluscous and conchiferous animals, for there is scarcely a membranous film that can be separated from the animal remains obtained by the maceration of these bodies in a weak solution of hydrochloric acid, in which exceedingly fine ramifying vessels may not be observed, provided a sufficiently high power be used in their examination; but this is absolutely necessary to a successful investigation of their structures, which requires powers varying from five hundred to one thousand linear to ensure distinct and satisfactory results. After the description of the tissues already named, it is scarcely necessary to say that, as a matter of necessity, there must be a free vascular communication between the animals inhabiting both univalve and bivalve shells and their habitations, through the medium of their points of attachment: but this fact is exceedingly difficult of demonstration; and, although I have used my best endeavours to trace the vessels both from the animal to the shell, and from the shell to the animal, I have not yet succeeded in detecting them in their passage from the one to the

other body, although I have found, at the junctions of the adductor muscle with the shells, both in Pinna and Ostrea, a layer of most elaborate and complex minute vascular tissue, and amid these other vessels, few in number and much greater in size. These vessels were evidently not those which appertained only to the mussel itself, as they were found in no other part of it, but concentrated in a single complex stratum at this point."

You observe, then, that Mr. Bowerbank concludes the shell to be highly organized and vascular, and that it retains, during life, a vascular communication with the animal it protects. It has a structure analogous to bone in some respects, and is formed much in the same manner by the deposition of carbonate of lime within the cells of the membranes of which shell is composed, or by the aggregation and coalescence of the calcigerous cells when the membrane is very sparingly produced. Let us go back to the Mollusk when yet within its egg, but far enough advanced to be endued with the rudiment of its future shell. We may suppose this rudiment to have been the result of the excretion of some mucus or lymph, and it is in fact nothing more than a very thin transparent membrane, with a determinate figure dependent on the figure of its species. In this membrane organizing cytoblasts and cells are produced and multiplied in rapid succession until, by their increase and apposition, a cellular structure is formed in it. On their first appearance the cells are transparent and globular, but, pushed on by the law of growth, which regulates their development, they very soon begin to secrete, from their inner surfaces, carbonate of lime. The cells being filled with it, a solid structure is the result of their close packing and aggregation, and this structure must, of course, exhibit the cellular structure whence it has been derived, the pattern being modified only by the form and degree of condensation of the calcigerous cells in which it has been secreted. As this deposition of calcareous matter proceeds, canals are also formed, which penetrate the layer, and another system of vessels which are destined to maintain its life by leading through it a circulation of fluids. A layer or stratum of shell being thus formed, another is produced from its inner surface, by the same production of a basement membrane and the same development and aggregation of calcigerous cells ; and then others until the normal number set for the species is completed, the whole being, however, kept together as one by the living tissues and vessels. Mr. Bowerbank thinks that the truth of this is proved not only by the structures he

has discovered in shell, but also by the phenomena which occur in its reparation of injuries, whether that injury is limited to the periostracum or inflicted on the substance of the shell itself; for this reparation is not made by a coat of calcareous matter spread over the wound by the collar or mantle of the animal, as has been maintained, but by an effusion of coagulable lymph in which cytoblasts are produced in the first instance, and quickly succeeded by a cellular structure, in which the earthy basis of the shell is secreted, and by which the scar is filled up, or the fracture cemented together.*

Dr. W. B. Carpenter entered simultaneously with Mr. Bowerbank on the investigation into the structure of shells, but as his objects were different, he was led to work after a more systematic fashion. Dr. Carpenter's principal object appears to have been to discover whether the microscopic structure of the shell was so peculiar and distinctive that from it we might conclude as to its genus or family, so that henceforth the conchologist, from an inspection of even a fragment of a valve or whorl, might rival the zoologist in conjuring up, on fixed principles, the image and character of a beast of whose existence he is only made aware by a few fragmentary remains. And Dr. Carpenter has been eminently successful so far as the bivalve shells are concerned; for there is too much sameness in the structure of univalves to give the same satisfactory results. This eminent physiologist has ascertained that an uniform structure prevails throughout every part of a shell, and, consequently, that the examination of but a very small piece suffices to determine its entire structure; and he has also ascertained that the species of the same genus present essentially a oneness in pattern, so that any material deviation from it indicates a family or generic difference in the structure of the animal. The conchologist who formerly broke the shell that he was quarrying from its ancient tomb, lost his labour and the key to the knowledge it might have disclosed to him; but now, if the shell be a bivalve, he has only to prepare a fragment of his shattered document, and the key is recovered that locked up in secrecy the world's former tenantry. Such is one result of Dr. Carpenter's curious researches; but in proving it he has necessarily discovered many important facts bearing on the subjects of this letter.

Dr. Carpenter concludes with Mr. Bowerbank, that all

* Observations on the Structure of the Shells of Molluscous and Conchiferous Animals, by J. S. Bowerbank, F.R.S., &c., published in the Transactions of the Microscopical Society, vol. i. 123. Lond. 1844.

the shells of molluscous animals possess organic structure, but he explains differently the appearances indicative of their vascularity, and denies their vascular connection with the animal. He bears witness to the correctness of Mr. Bowerbank's description of the structure of the univalves; but he discriminates with nicer precision the various structures exhibited by the bivalves. Of these beautiful organisms I could not give you an intelligible notion without the aid of the figures which illustrate Dr. Carpenter's Reports, and the attempt would be beside my purpose in this place, where I wish only to indicate the principal varieties—which are named the Cellular, the Membranous, and the Cancellated.

Of the *cellular* variety, the Pinna affords the most characteristic example. The shell is composed of a vast multitude of prisms, having for the most part a tolerably regular hexagonal shape and nearly uniform size. These are arranged perpendicularly, or nearly so, to the surface of each lamina, so that the thickness is formed by their length, and the two surfaces by their extremities. A "satisfactory view of these prisms is obtained by grinding down a lamina until it possesses a high degree of transparency, and it is then seen that the prisms themselves appear to be composed of a very homogeneous substance, but that they are separated by definite and strongly-marked lines of division. In general the substance forming the prisms is very transparent, but here and there is seen an isolated prism, usually of smaller size than the rest, which presents a very dark appearance, even in a section of no more than 1-400th of an inch in thickness, as if the prism contained an opaque substance." This opacity appears to be due to the presence of a small quantity of air in or near the extremities of the cells.

The *membranous* structure is the prevalent one, embracing all those shells that do not present the prismatic cellular tissue. In these the calcareous matter is deposited in laminæ separated by an excessively thin membrane, which forms, in fact, a secreting surface. No trace of cells can, for the most part, be discovered; and when they do present themselves, they are usually scattered through the substance with little or no regularity, and do not form a continuous stratum when the calcareous matter has been removed by an acid. "In no shell," says Dr. Carpenter, "even those most decidedly porcellanous, have I failed in detecting some membranous basis, although the film is often of extreme tenuity. I believe that there is no shell, in which this kind of structure does not exist under some

form; for even where almost the entire thickness is made up of the prismatic substance, as in Pinna and its allies, there is still a thin lining of nacre, which I shall presently show to be but a simple modification of the ordinary membranous structure."

Of this membranous structure there are two kinds, the nacreous and the tubular. The nacreous or pearly is produced by the membranes being crimpled with numerous very delicate folds; and these most fine folds being repeated in a regular manner, give to the pleased eye the mother-of-pearl lustre which so brilliantly distinguishes the inner surface of many shells. The nacre or pearl is not then produced, as has been maintained, by the alternation of numerous layers of membrane and calcareous matter; but is due "to the plication or folding of a single layer, in such a mode that the folds shall lie over one another in an imbricated manner."

The other kind of membranous structure is the tubular. "All the different forms of membranous shell-structure are occasionally traversed by tubes, which seem to commence from the inner surface of the shell, and to be distributed in its several layers. These tubes vary in size from about the 1-20,000th to the 1-2000th of an inch; but their general diameter, in the shells in which they most abound, is about 1-4500th of an inch. The direction and distribution of these tubes are extremely various in different shells; in general, where they exist in considerable numbers, they form a network, which spreads itself out in each layer, nearly parallel to its surface; so that a large part of it comes into focus at the same time, in a section which passes in the plane of the lamina. From this network some branches proceed towards the nearer side of the section, as if to join the network of another layer; whilst others dip downwards, as if for a similar purpose. The most characteristic examples of this structure which I have met with are to be found in the outer yellow layer of Anomia ephippium, the external layer of Lima scabra, and in Chama florida. In other instances, the tubes run at a distance from each other obliquely through the shelly layers, and they are then usually of large size. This is the case, for instance, in Arca noæ and Pectunculus. In no cases have I seen any such variation in the size of the tubes of the same shell, as would convey the idea of their resemblance to bloodvessels; and even where a division occurs, the size of each of the branches is usually equal to that of the single trunks. Sometimes these canals are quite straight, whilst in other instances they are sinuous.

That they are not mere channels or excavations in the shell-substance is proved by the fact that they may be seen in the decalcified membrane. I have frequently seen in them indications of a cellular origin, as if they had been formed by the coalescence of a number of cells arranged in a linear direction; and I find that Mr. Bowerbank has come to the same conclusion.

"The tubular structure is usually found only in the ordinary membranous shell-substance; in fact, I have seldom observed it in the nacre, except where the tubes penetrate this, to be distributed in a layer external to it, as is the case, for example, in Anomia and Trigonia. I have nowhere found it coexisting in the same shell with any great amount of prismatic cellular substance; consequently it is for the most part absent in the Margaritaceæ and Nayadeæ, and but very slightly manifested in the true Ostraceæ. In most of the families of bivalves, however, in which the lobes of the mantle are united, some traces of it may be detected; though these are often very scanty. There is less regularity in regard to this character, than in respect to most others furnished by the microscopic examination of the shell. Thus I have found a little collection of tubes in one spot of the nacre of an Avicula, in no other part of which did I meet with any; and I have frequently found one species of a genus extremely tubular, whilst another, closely allied to it, was almost or entirely destitute of tubes."

The third kind, or *cancellated* structure, resembles the cancellated texture of bone, and is characteristic of a very peculiar group of shells, named the Rudistes.* Dr. Carpenter compares it to the prismatic cellular structure on a large scale, with this important difference, however, that the prismatic cells are not solid but hollow. "In what manner these minute chambers were occupied during the life of the animal, it is impossible now to say; as there is no existing group, to which the Rudistes seem to bear any close resemblance. The shape of each is usually that of a very short hexagonal prism, terminated at each end by a flat partition: consequently a section in one direction will exhibit the walls of the chambers disposed in a hexagonal network; whilst, when the section passes in the opposite direction, the transverse partitions come into view. The cancellated structure is externally and internally covered with a shelly plate, in which no perforations whatever can be seen. It

* This structure was first described by Mr. J. E. Gray in the Magazine of Zoology and Botany, ii. 228—32. 1838.

is difficult to imagine, therefore, how any communication could have existed between the animal contained within the shell, and the cancellated structure which forms its thickness."

Now, as to the formation of these structures, Dr. Carpenter is at antipodes with Mr. Bowerbank in opinion. He views the shell as being not analogous to bone, but as the representation in the Mollusca of the cutaneous membranes, —the view which was taken of their relation to the animal by Cuvier and his followers.* We may pass over, in our statement of the theory, the formation of the basement or primary membranes by the successive production and coalescence of cytoblasts and cells, for this is merely a part of the general theory of the formation of membranes, but commence with the process after it has proceeded beyond this initiative.

I gather, then, from Dr. Carpenter's essays, that he considers the periostracum or skin of the shell to be cast off from the animal as an epidermis, and to be, consequently, inorganic. Beneath it an organized membrane or epithelium, derived from the mantle, is then detached, and, by the secretion of calcareous matter in its cells, is hardened into a layer of shell, which layer is thus nothing else but a calcified epithelium analogous with the enamel of the teeth. By the rapid and successive production of similar layers of exuvial membrane and of lime within its cells, the shell is ultimately completed in the following manner.

The shell of the animal in the egg consists, perhaps, only of periostracum, and at most merely of an additional layer of epithelium in which no lime has as yet been deposited.† By the growth of the animal a new edge of periostracum is added to the rim of that already formed, and underneath it a new rim also of calciferous epithelium, enlarging as a matter of necessity the shell in the direction of the animal's growth, and with an equal step. The thickening of the shell is at the same time carried on in the parts already traced by the deposition of calcareous layers,—a deposition which is the result of the casts of the secreting epithelium furnished by the underlying mucous skin of the mantle. The periostracum and cellular layers are then made by an extension of the margins of the aperture or valves by a secretion from the collar or edges of the mantle; but the nacreous layers proceed from secretions furnished by the mantle itself.

* Mem. xi. 8.

† "Ces deux valves primitives sont d'abord purement membraneuses. Le compresseur les aplatit sans les rompre," &c.—A. DE QUATREFAGES, *Embryogénie des Tarets in Ann. des Sc. Nat.* (1849) xi. 211.

I may advantageously lengthen this explanation by employing more exactly the language of Dr. Carpenter. He tells us that all shells are generated in the first instance by the agency of the epithelium of the mantle, the cells of which have the power of consolidating themselves by drawing calcareous matter into their interior. By successive casts of this exuvial membrane, the laminæ of the shell are increased in numbers. "The *margin* only," says Dr. Carpenter, "of the mantle, has the power of giving origin to the *outer* layer of the shell, whilst its *whole surface* may generate the *inner*. Every new production of shell consists of an entire lamina of the latter substance, which lines the whole interior of the old valve, and of a border or margin of the former which thickens its edge. So long as the animal continues to increase in dimensions, each new interior layer of shell projects so far beyond the preceding that the new border, composed of the outer layer, is simply joined on to the margin of the former one; so that the successive formations of the outer layer scarcely underlie each other. But when the animal has arrived at its full growth, the new laminæ cease to project beyond the old; and as each is still composed of a marginal band of the external substance, attached to the edge of an entire lamina of the inner, these bands must now underlie each other, being either quite free as in Ostreæ, or closely united to each other as in Unio and most other bivalves."—The additions to the shells of the Gasteropods are made upon the same plan.

Admitting the justness of this explanation it follows "that no addition can be made to the outer stratum after the subjacent layer has been formed, except by a deposition upon its external surface, as in Cypræa: nor can any change be made in the thickness of the middle stratum after the formation of the internal layer. But this last-formed internal layer may be thickened by successive deposits to any extent; and this appears to me to be the explanation of the fact that the thickness of the internal layer at some distance backwards from the lip, bears a considerably greater proportion to that of the middle and external layers than it does nearer the margin. "Upon measuring," says Mr. Bowerbank, "the relative degrees of thickness of the strata at different parts of the same shell, I found the following variations. The thickest part of the stratum of plates near the mouth of a young Ampullaria, which were parallel to the lines of growth, may be represented by the number 25. At half the revolution of a whorl backwards the same stratum was represented by 20, while the new stratum beneath

it measured 13; total 33. At a whole revolution backward the upper stratum measured 18, and the lower or new one 20; the older of the two thus appearing to decrease gradually in thickness as the younger grew in substance. Upon examining, in a like manner, an adult specimen of Bulimus oblongus, the proportions of the strata near the lip were as follows:—Outer 10, central 14, inner 17; total 41. But at one revolution backwards they were—outer 5, central 5, inner 19; total 29." This fact harmonizes well with the preceding explanation, for it simply indicates that whilst the thickness of the whole shell undergoes a considerable increase near the lip, that increase is due to the greater developement of the outer and middle layers, the inner layer being positively thinner than it is at a distance from the lip, where it has been thickened by successive deposits. I can see no reason to attribute the foregoing differences in the relative thickness of the three layers at different parts of the shell to any absorption or removal of the outer layers, as Mr. Bowerbank seems inclined to do, for it seems impossible to imagine that the external and middle layers can be thinned by absorption without the removal of the inner layer, since any absorbent action must take place from within, being effected by the surface of the mantle. I am far from denying that such absorption does take place; but the explanation is not applicable to the facts just cited, which seem to me to indicate clearly that the formation of the inner layer is progressive, and not completed at one effort. The truth appears to me to be, that whenever an addition is made to the shell, the outer and middle layers are simply joined on to the edges of the old margin, but that the internal layer is carried backwards for a certain distance into the interior of the shell, where the new formation forms a lining to the old, and increases its thickness just as in the bivalves. I have never been able, however, to trace it very far back, and it certainly can seldom or never line the whole shell, as it does in most bivalves. But this new layer seems to cover that part of the internal surface which is in contact with the moving parts of the animal; and thus serves to prevent that irregularity which could scarcely fail to exist were the new internal layer, like the middle and external, simply joined on to the edge of the preceding."*

* Dr. Carpenter's Essays on the Microscopic Structure of Shells are contained in the Reports of the British Association for the Advancement of Science, 1843, p. 71; 1844, p. 1—23; 1847, p. 93—117; and in Ann. and Mag. N. Hist. xii. 377—86.

The theory, as thus expounded by Dr. Carpenter seems to be the true one, and it recommends itself the more that it can be easily reconciled with the experiments of Reaumur. Indeed, the theory of the French naturalist differs in little or nothing from the one now proposed except in considering the excreted lime as consolidating itself from a mechanical cause, instead of being moulded in the cells of a secreting membrane. Hence there is much in the old doctrine which needs no change of expression to suit it to the newer physiology; and this in particular is the case with that part of it which relates to the colouring of the shell. The colour is situated always in the outer layers, partially dimmed in many by the periostracum, and, therefore, it must be furnished solely from miliary glands situated in the collar or edges of the mantle. All the varieties of colours, and all their varied and mixed patterns which render shells so attractive and pleasing, are the result of the arrangement of these glands, and on their secretion of the colouring matter being uninterrupted, or interrupted at regular intervals.

In a great number of Mollusca it would appear that the increase of the shell from birth to mature size is uninterruptedly progressive; but there are, perhaps, an equal number, in which the animal, at certain and determined intervals, forms a transverse rib or varix, and seems to become for a season inoperative. These ribs vary much in their numbers, in their figure, and in the distances at which they are placed in different shells, but in the same species are alike and uniform, so that it would perhaps be better at once to refer their formation to a law of their individual life imprinted on them by their Creator, than to seek for its explanation in causes which are only partially applicable, or of doubtful existence. We may suppose, indeed, with De Montfort and Blainville, that, during the season of love, the derivation of fluid and of energy to the generative system may diminish the secretion of fluid and of lime from the cloak, and that then the growth of the shell goes on as usual, as is indicated by the plain intermediate spaces. We may further suppose, that, when the seminal turgescence has subsided, the fluids are carried in greater abundance to the skin, whence an accumulation of calcareous matter in the margins of the collar, and a consequent varix or rib. We may make such or similar suppositions,* but they are idle and improbable; and I men-

* Lamarck supposes that on the addition of every new piece which the growth of the animal obliges it to make to its shell, the Ranella comes out and exposes itself for the entire length of an half volution, and thus remains

tion the hypothesis rather from respect to its able advocates than from any the slightest conviction of its truth. It is inconsistent with analogy to believe that the Mollusca are influenced by the sexual passion long previous to the attainment of maturity; yet the hypothesis assumes that some of them feel its power almost from the date of their birth, and afterwards at very short and frequent intervals; while others, of the same genus even, are swayed by it at distant periods, and only two or three times during the term of their existence. And in what predicament are those which are plain and ribless? Are we to believe that their life is love unceasing; or that it begins only when the animal reaches maturity, and is about to finish the aperture of its edifice?

In the progress of its formation, the shell of every class is moulded on the mantle of the animal, and when placed in your cabinet you have in the shell a permanent cast of the form and the main peculiarities of the latter. Every line and plait of the mantle is most accurately imprinted on the inner surface of the shell, so that from its examination we may often derive very correct information relative to the inhabitant's organization, and some of the most assured characters for distinguishing the genera. You may say to the shell by and bye, when your knowledge is riper,—

> "There is a kind of character in thy life
> That to the observer doth thy history
> Fully unfold."

Whenever the edge of the mantle is furnished with any fold or protuberance, with processes or beards, corresponding processes on the shell declare the fact; and these processes are cast in the form of cases for the protection of the fleshy parts they represent. If the original make of the mantle continues during life invariably alike, the surface of the shell is conformable and uniform, either smooth and even, or marked with striæ and ridges that extend from the apex to the edge in uninterrupted lines. You may easily satisfy yourself of this by examining the collar of the common snail, which is as even as its shell, and the edge of the

stationary until the new half volution is formed; a fact, he says, which is proved by an examination of the shell, and evidenced by the varices being constantly disposed on the two opposite sides. I have heard this opinion maintained by conchologists, but it cannot be even discussed by those who have studied the theory of the formation of shells. Sowerby and Deshayes have animadverted on the hypothesis of Lamarck sufficiently. Gen. of Rec. and Fossil Shells in verb. Ranella: Lam. Anim. s. Vert. 2nde edit. ix. 538.

mantle in the common cockle, which is regularly raised and depressed at short intervals, corresponding to the grooves and ribs of its shell. But very often these fleshy appendages of the mantle appear to be developed only at certain periods, and, after the orgasm is over, again to fall and subside into inactivity. In their times of development cases of calcareous matter are formed for their protection, and, before the animal proceeds to add a new piece to its domicile, it fills up these cases more or less completely with shelly matter, which then remain, in the form of cross-ridges, to constitute the shell's principal feature and beauty. In this manner are formed the vaulted spines on many Cockles; the strap-like processes of the Spondyle; the thick ribs that gird many Rock-shells; the spinous, pectinated and foliated processes of many other Muricidæ; and, in short, all the irregularities and inequalities which appear, at interrupted intervals, on the surface of every shell.

But although, from the preceding remarks, you might expect to find an index to the animal's organization in the exterior aspect and model of the shell, yet you must consult the index with heedful caution, for if solely depended upon, it will occasionally mislead you. This is now admitted. Montagu affirms, "that similar shells are sometimes inhabited by very different animals."* Cuvier has frequently insisted on this fact; and Mr. Collier goes so far as to say, that "many Mollusca, alike in form and structure, inhabit shells so essentially different in character, as to render the union of the two modes of distinction impossible."† In a book which happens to lie on my table, I find an apposite example in a new species of Mollusk, found by Mr. Alder at Dalkey Island, near Dublin. The shell was in all respects similar to that of the genus Rissoa, but the snail had four, and not two, tentacula; and the eyes were placed on the back at some distance behind the tentacula, and not at their base.‡ This subject, which is one of considerable importance to the geologist, has been handled so ably by Mr. J. E. Gray, that I cheerfully avail myself of his permission to send you his remarks, unmutilated.

* Test. Brit. pref. iii. † Edinb. New Phil. Journ. vii. 225.
‡ Reports Brit. Assoc. 1843, Trans. p. 74.

"*Of Shells apparently similar, but belonging, on a comparison of their Animals, to very different Genera.*" By John Edward Gray, Esq., F.R.S., &c. (Reprinted from the Philosophical Transactions, part ii. 1835.)

"In a note on my former paper on the structure of shells,* I pointed out the perplexity in which the extreme similarity of the shells belonging to the genera Patella and Lottia must involve the geologist and the conchologist, intending at some future time to pursue the subject further, and to show that similar difficulties existed in regard to several other genera. The two genera above referred to are probably, however, the most remarkable example of this complete resemblance, on account of the extreme dissimilarity of their animals, which are referable to two very different orders of Mollusca, while the shells are so perfectly alike, that after a long-continued study of numerous species of each genus, I cannot find any character by which they can be distinguished with any degree of certainty. Both genera present a striking discrepancy from all other univalve shells, in having the apex of the shell turned towards the head of the animal, the genera to which they are immediately related in both the orders to which they belong offering no variation in this respect from the usual structure of the class. The agreement in the internal structure of their shells is equally complete; yet the animal of Patella has the branchiæ in the form of a series of small plates disposed in a circle round the inner edge of the mantle, while that of Lottia has a triangular pectinated gill seated in a proper cavity formed over the back of the neck within the mantle, agreeing in this respect with the inhabitants of the Trochi, Monodontæ, and Turbines, from which it differs so remarkably in the simple conical form of its shell. This difference in the respiratory organs of animals inhabiting shells so strikingly similar is the more anomalous, inasmuch as those organs commonly exercise great influence on the general form of shells; a circumstance readily accounted for when we reflect that a principal object of the shell is to afford protection to those delicate and highly important parts.

"To the practical conchologist it will be sufficient to mention Pupa and Vertigo, Vitrina and Nanina, Rissoa and Truncatella, as affording numerous and perplexing instances of the difficulty of distinguishing between genera of shells, inhabited by very different animals.

* Philosophical Trans. 1834, p. 800.

"A similar difficulty exists with regard to Siphonaria and Ancylus, genera belonging to two different families, one inhabiting the sea-shores, while the other lives in rivers and brooks. The only distinction between the shells of these two genera consists in the Ancyli being generally of a thinner substance than the Siphonariæ; but this is by no means an adequate character, some species of Siphonaria (S. tristensis, for example) being quite as thin in texture as any Ancylus. Both have the muscular impression interrupted by the canal through which the air passes to the respiratory organs; yet the animal of Ancylus has long tentacles, and eyes placed as in the Lymnææ, to which it is closely allied, while Siphonaria has no distinct tentacles, and in these respects agrees with the equally marine genus Amphibola, confounded by Lamarck with the Ampullariæ.

"About fifteen years since, I first observed, in the marshes near the banks of the Thames between Greenwich and Woolwich, in company with species of Valvata, Bithynia, and Pisidium, a small univalve shell, agreeing with the smaller species of the littoral genus Littorina in every character both of shell and operculum; yet this very peculiar and apparently local species has an animal which at once distinguishes it from the animal of that genus, and from all other ctenobranchous Mollusca. Its tentacles are very short and thick, and have the eyes placed at their tips; while the Littorinæ, and all the other animals of the order to which they belong, have their eyes placed on small tubercles on the outer side of the base of the tentacles, which are generally more or less elongated. The shell in question and its animal were described and figured by Dr. Leach, in his hitherto unpublished work on British Mollusca, under the name of Assiminia grayana; and as this name has been referred to by Mr. Jeffries and other conchologists, it may be regarded as established, and that of Syncera hepatica, proposed by myself in the 'Medical Repository,' vol. x. p. 239, will take the rank of a synonym. A second species of this genus has lately been made known by Mr. Benson, by whom it was found in ponds in India. Its shell is banded like that of Littorina 4-fasciata and several others of the smaller Littorinæ, and had been figured in the Supplement to Wood's Catalogue, t. vi. f. 28, under the name of Turbo francesiæ.

"Taking this in conjunction with the preceding, we have here two instances of univalve shells apparently belonging to the same genus, the one found in fresh and the other in salt water, but proving, when their animals are examined, to belong to genera essentially distinct. My next illustration

will show that a similar fact has been observed among the bivalves.

"The Mytilus polymorphus of Chemnitz is truly a fresh-water species, having been first observed in the Wolga by the illustrious Pallas. It has recently been introduced, doubtless with the Russian timber (for this species, in common with the Ampullariæ, Paludinæ, and Neritinæ of fresh water, and the Littorinæ, Monodontæ, and Cerithia of salt, has the faculty of living for a very long time out of water), into the Lake of Haarlem and the Commercial Docks at Rotherhithe; in both of which it appears to increase with great rapidity. I am aware that Mr. Lyell has given another explanation of the mode of introduction of this remarkable species; but from experiments which I have myself made on the animal's power of living out of water, I cannot hesitate in giving the preference to the suggestion advanced above, rather than supposing it to have made its passage from one river to the other, across the sea, attached to the bottom of a vessel. The shell in question differs from the shells of other Mytili in no character of more than specific importance; but the animal is essentially distinct. In the genus Mytilus the lobes of the mantle are free throughout nearly their whole circumference, as in Unio, Cardita, Pecten, Ostrea, &c.; while in the animal of Mytilus polymorphus they are united through nearly their whole extent, leaving only three small apertures, one for the passage of the foot and beard, and the other two for the reception and rejection of the water, from the contents of which the animal derives its sustenance. This shell must consequently form a new genus, to which the name of Dreissena has been appropriated by Van Beneden.* As a proof of the importance attached to this character, it may be observed that Cuvier considered the adherence or non-adherence of the lobes of the mantle so essential a distinction as to found on it his division of the bivalves into families. In his system, therefore, the genus Dreissena would be placed with the family of Chamacées, while the genus Mytilus forms the type of the preceding family of Mytilacées. The genus Iridina, however, and one or two others, show that this character cannot be implicitly relied on for the natural classification of animals of this class, although it forms a very good generic mark of distinction.

"The genus Iridina † above referred to affords a second instance of this anomaly; for though the animals of the

* Institut., 1835, p. 130; and Ann. des Sc. Nat. N.S. iii. 193.

† Lamarck formed this genus on a specimen which had its hinge-margin accidentally tubercular and slightly crenated; but this character is not found

Iridinæ and Anodontæ differ in the adhesion and non-adhesion of the lobes of the mantles, yet the shells are so alike that they cannot be distinguished by any external character; so much so, that one of the species now referred to the genus by M. Deshayes, who first pointed out this peculiarity in the animal, was considered as an Anodon by Lamarck.

"The animals of Cytherea, Venus, and Venerupis have, like those of most of the allied genera, a lanceolate foot projecting at the anterior part of the shell; while the genus Artemis of Poli, which has generally been confounded with Cytherea, from which it is not easily to be distinguished except by its usually more rounded form, is provided with a crescent-shaped foot, exserted at the middle of the lower edges of the valves.

"Again, there is but little difference in external characters and habit between Cyclas and Pisidium; but the animals of the latter have elongated siphons which are not found in the former.

"In reference to Univalves it may also be observed, that it is frequently impossible to distinguish some of the genera of that class without an examination of their opercula. This is the case, for instance, as regards the smaller and more solid Paludinæ, inhabitants of fresh water, and some species of Littorina living on the coast; several of the shells described as Paludinæ by Drapernauld and others appearing rather to belong to the latter genus. A similar difficulty exists with respect to other Littorinæ as distinguished from Phasianella, and with the Neritinæ as distinguished from the Neritæ. In the latter case the characters derived from the operculum are so essential to the discrimination of the two genera, that M. Rang, looking only to the characters of the shell, has proposed to reunite them into one. In proof of the little attention that has hitherto been paid to this very important part, I may mention that three species referred by Lamarck to the genus Solarium are each furnished with a different kind of operculum; and it is deserving of notice that the Monodonta canaliculata, according to the observations of M. Quoy, has an operculum very different from the rest of the shells of that genus.

"In some shells, again, the differences in character are so slight as almost to throw an air of ridicule on the attempt to separate them generically from the structure of the shells

in most of the specimens of the species which he describes. The English conchologists, misled by this character, have referred to the genus a very different African shell, with a long series of transverse teeth on the hinge-margin, which has lately been separated by Mr. Conrad under the name of Pleiodon.

alone; and yet when the animal is examined the necessity of their separation becomes so obvious as to be immediately acknowledged. This is especially the case with my genus Bullia compared with Terebra: the shells of these two genera are so similar, that Lamarck and all other conchologists have retained them in one group, no other distinction being observable except that in the former there is a more or less distinct callous band winding round the volutions just above the suture, and produced by a slight extension of the inner lip beyond the part of the shell occupied by the whorl. This extension of the lip is probably deposited by the foot of the animal, which in the genus Bullia is very large and expanded, while that of Terebra is small and compressed. This, however, is not the only difference between the two animals, that of the former genus having rather large and eyeless tentacles, while the Terebræ have very small and short tentacles, bearing the eyes near their tips.

"A second example of a similar kind is derived from the genus Rostellaria, in which Lamarck includes the Strombus pes-pelecani of Linnæus. The animal of this shell has been figured by Müller, and very much resembles that of Buccinum, having long slender tentacles with the eyes sessile on the outer side of their base; while, as Dr. Rüppell informs me, the Rostellaria curvirostris has an animal allied to Strombus, with the eyes on very large peduncles, which give off from the middle of one of their sides the small tentacles. Notwithstanding this difference in the form of their animals, I am not, however, aware of any essential character by which the shell of Aporrhais (as the Strombus pes-pelecani has been generically named) can be distinguished from the other Rostellariæ.

"With all this uncertainty with regard to the generic characters of the recent species of shells, of which the animals can be subjected to examination, how much must the difficulty of deciding their genera with certainty be enhanced with reference to the fossil species, and especially to those which have no strictly analogous form existing in the recent state. Considerations like these tend greatly to disturb the confidence formerly reposed in the opinion that every difference in the form and structure of the animal was accompanied by marks permanently traced upon the shell, by which it might be at once distinguished, and which it was therefore the great object of the conchologist to point out."

LETTER XXIII.

ON THE FORMATION AND STRUCTURE OF SHELLS.

BY JOHN EDWARD GRAY, ESQ., F.R.S., &c.

*** Reprinted by permission of the Author from the Philosophical Transactions for 1833.

1. *First Formation of Shells.*

The shells of Mollusca appear to be coeval with the first formation of the animal: they may be observed covering the embryo on its first development in the egg, even before it has acquired its proper shape or any of its internal organs. The accurate Swammerdam observed them in the eggs of several of the garden and pond snails. His observations have been recently verified and extended by Pfeiffer, on many species of land and fresh-water Mollusca; and I have myself observed the same fact in the eggs of several animals belonging to the different orders of marine shells; there is reason, therefore, to believe that this circumstance is general throughout the class. These observations are most easily made on the embryo of the fresh-water shells, such as the Lymnææ, Physæ, Ancyli, and Bithyniæ, the eggs of these animals being covered with a transparent coat; while the viviparous Mollusca, and especially the Littorinæ, Paludinæ, and Cyclades,* offer the additional advantage of exhibiting the embryos of their animals in all the different states of development at the same time.

* Between the laminæ of the branchiæ of the Anodontes and Uniones are found small cordate, bivalve bodies, which have been considered as their young; but they differ so much in external form and internal structure from the adults, that many excellent naturalists, and especially Professor Jacobson, of Copenhagen, have considered them as parasites. It is, however, remarkable that they are found in abundance in almost every specimen, and Pfeiffer has apparently proved that they are the young, he having found them constituting the umbones of very minute Uniones. I have searched for them in vain in this situation; perhaps because I have never been so fortunate as to discover specimens of the young shell so small as those figured by this author. If Pfeiffer should prove to be correct, this remarkable change of form and structure will be the only approach towards a metamorphosis that has been hitherto observed in this class of animals.

The cephalopodous Mollusca form no exception; their bone, composed of two or three calcareous plates, being found fully developed in the egg of the Cuttle-fish some time before the young animal is hatched.

These observations are directly at variance with the theory maintained by the late Sir Everard Home,* viz., that the shell of the Vermes Testacea is formed after the animal has quitted the egg; and as regards the Cuttle-fish, they are opposed to the remark, made by the Baron Cuvier, that the young Cuttle-fish, when first hatched, has only a cartilaginous plate like the Loligo.

The shell when first observed on the embryo (even of the animals of spiral shells) forms a short, blunt, more or less curved, subcylindrical cone, covering the hinder part of its body: as the organization of the embryo becomes developed, and the hinder part of the body extended, the shell increases in size, till the body and shell together occupy nearly the whole of the egg. While inclosed in the egg, the embryo shells are generally of a pale horn colour, and destitute of markings: when, therefore, they remain attached to the apex of the spire of adult shells, they may be easily distinguished by their appearance from the part formed after their exclusion; and as, in such cases, they offer some characters of importance, it has been proposed to designate them by the name of the nucleus of the shell.

The effect of the atmosphere on the shell is almost instantaneous: in some young Helices and in a species of Voluta in my collection, the very first line of calcareous matter deposited after their exclusion from the egg is marked nearly as the adult shells of the species.

The nucleus may be generally distinguished from the perfect shell by the rapid enlargement of its whorls, by its extreme tenuity, by its want of colour, and by the great obtuseness of that part which is earliest formed and constitutes the extremity of its first volution. It is necessary to pay attention to these particulars, inasmuch as the nuclei of some large species have been mistaken for full-grown shells, and *vice versâ*. Thus, the Murex decollatus of Pennant is the just-hatched shell of the Fusus despectus; Risso's genus Orbitina is established on the nuclei of two land shells; and the genus Vitrina was regarded by Montagu as the nucleus of the common snail. In some instances the first half-whorl of the nucleus (the part first formed on the embryo), instead of being regularly curved, is bent across the tip of the other

* Philosophical Trans. 1817, p. 229.

whorls, as in the Pyramidellæ, or placed in an oblique position with regard to the succeeding one, as in Voluta papillosa and some other species.

The nuclei of many shells of different genera have not the same characters as their parent shells; thus, the nucleus of the Tritons has a short anterior nick instead of an elongated canal, and is very like a minute Buccinum. Some retain the generic, but not the specific character of the group to which they belong; thus the nuclei of the Volutes in general have the pillar slightly plaited, but the young of Voluta musica has only two or three plaits on its pillar, while the adult has many.

The nucleus forms the original apex of the valves of all shells, whatever may be their form, and frequently remains attached to them during all their periods of growth; this is particularly the case with the Volutes, in which, from its large size and rounded shape, it has been called the Nipple. It is also conspicuous on most of the species of Dolium and on some Fusi, among the univalves; and on the apices of the valves of the Cyclades, and Chamæ, among the bivalves.

This part of the shell has not received the attention that it deserves. It is largest in those shells the animals of which are viviparous; and is consequently very distinct in the Volutæ, Paludinæ and Cyclades. In the oviparous species it agrees in size with the egg of the animal; thus Achatina octona, which has an egg nearly equal in dimensions to the mouth of the shell, and Bulimus ovatus and B. bicarinatus, which have large eggs, have large nuclei, the magnitude of the nucleus in general rendering the top of the spire blunt. Some shells on the contrary, those, for instance, of the genus Stylina, generally, and of the Pupa purpurea, have a very long, slender, acute, turreted nucleus, but the form and size of the eggs are in these cases unknown.

The nucleus is found on examination to consist of two very distinct parts or coats, the outer of which is membranaceous or horny, and called the Periostracum, and the inner hard and calcareous, and constitutes the shell.

These two coats may be observed in all the stages of the shell: they are generally very thin in the nucleus, and the outer one is rarely distinctly visible in that state; but it is to be clearly seen (covered with five or more bands of hair-like processes) in the very young Paludinæ. In such shells as are enveloped in the mantles of their animals, as the Dolabellæ, Aplysiæ and Bullææ, the outer coat or periostracum is very thin; it is, however, to be found in all shells, and

may also be observed on the shelly plates of the Cirrhipedes. In some instances, as in the Cowries and Melons, the outer coat of the shell is covered in the adult age with a deposition of shelly matter, which entirely conceals it from view. A few shells, as for example those of Loligo and Aplysia, contain so little calcareous matter, as to appear to be formed entirely of periostracum.

2. *The External Form of Shells, and their Variations.*

Each valve of a shell, according to the manner in which it is first formed and subsequently increases, is a more or less depressed or lengthened cone. The apex of this cone is always oblique: in all the shells with which I am acquainted, it is excentric; and in most of the univalve shells, whether they be simply conical, involute or spiral, it is directed from the head of the animal towards the hinder part. The only exception, as far as I know, to this rule, occurs in the genera Patella and Lottia, in which the apex is directed from the hinder part towards the head; and this is the more remarkable, as in the Chitons, the animal of which so much resembles that of Patella, each of the valves takes the usual direction. The similarity of direction in the two genera above named is still more curious, as their animals bear scarcely any resemblance to each other.

The nucleus of the bone of the Cuttle-fish and of the Loligo, is placed in the same direction; for it is the conical process at the end of the bone of the Cuttle-fish (called Beloptera, when found in the fossil state), which must be regarded as the nucleus of these shells. If, however, the relative position of the animal of the Nautilus, the anatomy of which has been admirably described by Mr. Owen, be correctly assigned by that author with respect to its shell, it must offer a similar anomaly with the genera Patella and Lottia. The shells of the Pteropods, as for example Hyalæa, Cleodora and Vaginella, take the same direction as the other univalves; and it was this circumstance that gave rise to the supposition that M. de Blainville, in his figure of the animal of Cymbulia, had placed it in the shell in the wrong position. The numerous specimens which are now in European cabinets have proved the accuracy of this supposition.

In bivalve shells the apex of each valve is always placed on or near the dorsal or hinge margin, varying its position on this part in the different groups. Thus, in the Pectines and other suborbicular shells, which having a very large

subcentral posterior adductor muscle, were called by Lamarck Monomyaires, the apex is generally in or near the centre; while in most of the other genera it is placed more or less towards the anterior extremity of this margin, and is sometimes incurved.

In some of these shells the apex is spirally twisted, and the spire becomes more developed as they increase in size. Now this could not take place if the valves remained inseparably united together at the same part of the dorsal margin; but it is provided for by the hinge of the shell being gradually moved backwards on the edge of the valves, the ligament separating in front of the hinge into two parts, one of which diverges along each of the umbones, and forms a spiral groove down the suture of the whorls. In Isocardia the umbones seldom make more than half a turn, but in one specimen of Chama in my collection they have made an entire revolution, and in another a revolution and a half. The valves of these shells being unequal, the spiral part of the lower or attached valve is produced into an elongated cone, while in the other it is depressed, and simply marked with a spiral groove, like that of an operculum.

In most bivalves the hinge-margin, which is deposited by a part of the mantle extended behind and between the teeth, increases in size much more slowly than the other margins of the shell; but in some free shells, such as the Arcæ, this part increases nearly as rapidly as the rest, and the umbones thus become separated from each other by a lozenge-shaped disk. In others which attach themselves to foreign bodies, as the Spondyli and Ostreæ, the hinge-margin of the attached valve only enlarges, forming a triangular flat-topped process, while that of the upper valve is scarcely increased in size. Thus the cavity of the shell, as the growth proceeds, gradually retreats from the part by which the attachment first took place.

The direction followed by the whorls in passing down the axis derives its origin from that which the shell takes in the egg; and is probably dependent upon the direction in which the embryo rotated whilst enclosed therein. In most shells they turn from left to right, and the mouth is on the right side of the axis, when the shell is in its natural position; but in others, which are called sinistral or reversed, the whorls are twisted in the contrary direction. The sinistral direction appears to be constant in many species, especially among the air-breathing Mollusca; in all belonging to the genus Clausilia, among the land ones; and in all the Physæ, Planorbes and Ancyli, among those which inhabit fresh

water. But besides these entire genera, the shells of which are invariably sinistral, there are numerous species of Bulimus, Partula, Pupa, and Chondrus, that are uniformly so twisted; and there are even some that are sometimes twisted in one direction and sometimes in the other, as Bulimus lyonettianus, B. aureus, &c. Among the marine shells the sinistral direction is much more rare, although there are a few species, such as Fusus sinistrorsus of Deshayes, F. contrarius and F. sinistratus of Lamarck, and some species of Cerithia, which are constantly so contorted. The Pyrula perversa is as often found twisted in one direction as in the other, and its shells have even been considered as different species according to the direction of their whorls. Of other marine species liable to the same variation, I have observed Buccinum undatum, which is not uncommonly found reversed; Turbinella napus, the reversed variety of which is much sought after by the Chinese; Oliva oryza, Nassa reticulata and N. thersites; but there are some genera in which I do not recollect to have noticed its occurrence; as, for example, the Cyprææ and Ovulæ.

A bivalve shell is composed of a dextral and a sinistral valve, united together by a ligament. When the two valves are separated, and spread out on a table with the umbones above, and the front end towards the observer, the valve to the right (the left when on the animal and in its usual walking position) resembles a dextral, and that to the left a sinistral, very depressed spiral shell. This is well illustrated by comparing the left valve of an Isocardia with a Concholepas. In some very rare instances these shells are also reversed, but the fact is not easily observed, except in the unequal-valved kinds. There were formerly in the Tankerville collection two specimens of Lucina childreni, in one of which the right valve was a dextral shell, in opposition to the general structure. A much more remarkable variation is to be observed in some of those bivalve shells whose under valve is attached to foreign bodies; thus, for example, most of the Chamæ are attached by their left valve, but some species, such as Chama lazarus, are frequently attached by their right valve, under which circumstance the teeth proper to the left and usually attached valve are transferred to the right, and *vice versâ*.

The equality or inequality of the valves of bivalves appears to be dependent on the habitual position of the animal. Thus all the genera whose animals bore perpendicular holes in rocks, like the Pholades; or bury themselves in the mud of rivers, as the Uniones; or in the sand of the sea-coast, as

the Cardia; or walk freely about on the shores, as the Veneres; or are attached by a byssus which passes out of a gape formed by the inflection of the margins of both valves, as the Tridacnæ, Saxicavæ and some Arcæ, have equivalve shells: whilst on the other hand, all those Mollusca whose shells are immediately attached by the outside of one of their valves, as the Etheriæ, Ostreæ, Spondyli, Hinnites and Chamæ; or of which the animals are attached by a byssus passing through a groove near the umbo of one of the valves only, as the Pectines, Aviculæ, Peda and Anomiæ; or which lie free on the surface of one of their valves, as the Ostreæ, Anatinæ, and some of the Arcæ, are more or less inequivalve. In those inequivalve shells which are attached by the intervention of a byssus, this substance passes out through a groove in the right valve, which is the smallest; whilst, on the other hand, in those that are immediately attached by the outside of the shell, the right valve is affixed, and the left is the smallest, sometimes indeed so disproportionately as to appear like a lid to the other. It is only in the families Ostreidæ and Anatinidæ, which always lie on their sides, and have unequal valves, that there are found some genera entirely free, and others which are immediately attached. The free inequivalve shells offer some curious anomalies in the relative size of their valves; nearly all the Anatinidæ, as Anatina, Periploma and Magdala, having the left valve the smaller, as have also the genera Corbula and Sphænia of the family Myidæ; whilst the other two genera of that family, Mya and Pandora, and Lyonsia among the Anatinidæ, have the right valve the smallest.

In the Terebratulæ and Branchiopodous Mollusca in general, the valves being applied to the dorsal and ventral, instead of the lateral surfaces of the animal, their lateral halves are analogous in situation to the right and left valves of other bivalves, and the byssus by which the animals are attached passing through a hole in the centre of the dorsal valve, the sides of the shell are equal. The dorsal or perforated valve is superior and convex in all the genera of this order, with the exception of Discina, in which, the usual position of the animal being reversed, it is inferior and flattened.

In all shells, the young of which I have had an opportunity of observing, the nucleus or shell of the animal when first hatched is regular. The irregularity in the form of adult shells appears to depend on their becoming attached to foreign substances, for it is only among attached shells that any irregularity of form is found, and even these are per-

fectly regular so long as they continue free. This explains why irregular shells are more rare among the univalves than among the bivalves, as not more than three or four genera of the former ever became attached. Good examples of shells which are irregular when full grown, although regular in their very young state, may be seen in the genera Ostrea, Chama, Hinnites, Magilus, and Vermetus. The very young shell of Chama arcinella, which closely resembles in form a minute Petricola, is frequently found persistent and constituting the apex of the umbones of adult specimens; and so regular is its form, that I have little doubt, were a conchologist to meet with a very young free specimen among the sand of the West Indian coasts, that he would refer it either to the latter genus, or to the genus Cardita. In like manner the very young shell of Hinnites pusio, when persistent in the umbones of the adult, cannot be distinguished from a free regular Pecten.

Many univalves exhibit the same phenomenon: the young Spiroglyphus and Magilus, as will hereafter be described, are quite regular so long as they remain free; and the apices of all the Vermeti and Siliquariæ show that they also are regular in their youth. The apex of the former has indeed been mistaken for a regular spiral shell, and described as a Turritella by Lamarck and by Dr. Turton.

Some land shells (for it is only in such shells that I have observed it) offer a very curious anomaly in their form; they are quite regular in their young state, but change the direction of their last whorls as they approach maturity, and in some cases even reverse the position of the mouth. A remarkable instance of this change of direction occurs in a rather common Brazilian snail, which is transversely striated in its young state, and exactly resembles a common umbilicated snail; but acquires when adult a smooth last whorl much larger than the others, and pressed towards the side next the mouth, by which means the axis is bent out of the line, and the umbilicus is compressed and closed. This obliquity in the form of its whorls gives the shell the appearance of having been slightly crushed, from which circumstance it has been called by Baron Férussac Helix contusa. A similar departure from the regular form is found, in even a greater degree of development, in a minute species from the same country, named Helix deformis (Wood's Supplement, tab. 7. fig. 40); and may also be seen in a slight degree in the Helix concamerata of Wood's Supplement, tab. 7, fig. 21. The last whorl of Bulimus lyonettianus is compressed on the side opposite to the mouth, and produced into

an acute angle, which gives the shell a very anomalous appearance. A somewhat analogous deformity, but not so much developed, may also be observed in Helix auris-leporis. This kind of variation is, however, not confined to the inoperculated land shells, for the Cyclostoma compressum, figured by Mr. Wood in his Supplement, tab. 6, fig. 42, differs from all others of the genus in its last whorl being compressed, although not in so great a degree as in the Bulimus lyonettianus; and in the Cyclostoma tortum (Turbo tortus of Wood's Supplement, tab. 6, fig. 32), the last whorl is slightly pressed on one side like that of Helix contusa, the mouth being produced in front, and nearly in a line with the axis.

But the most remarkable of these anomalies occurs in the genus Anastomus, where the mouth of the young shell occupies its ordinary situation in front of the whorls, the animal in this early stage doubtless crawling in the usual manner, with the spire of the shell uppermost; but as it approaches maturity, the end of the last whorl is curved upwards, and the mouth of the perfect shell is applied to the upper edge of the last whorl but one, with the opening directed towards the tip of the spire in such a manner that, in walking, the animal must crawl with the tip of the spire downwards, and thus completely reverse the position of its shell. A similarly formed shell has been discovered in the fossil state, and named Strophostoma; and this from the roundness of its mouth, has been supposed to belong to the family of Cyclostomidæ.

The axis of most spiral shells is perfectly straight, but the species of some few genera, such as Eulima and Stylifer, are very liable to have it more or less curved or twisted. And this is not the only point of resemblance between these two genera, both having the same polished surface and similar varices on the spire; but they differ in the degree of solidity of their shells. The Styliferi live buried in the substance of Star-fish, which may perhaps account for their inflections: the habits of the Eulimæ are unknown.

The growth of other spiral univalve shells appears never to be thrown out of its proper course, except by some accident, such as the interruption caused by the occasional attachment of a foreign body, or by a fracture. I have a Fusus virgo and a F. colosseus, which are thus bent; and there are two specimens of the common Whelk in the British Museum, the spires of which are very much elongated, the elongation having evidently been caused by a fracture in their very young state. One of the latter has been described as a dis-

tinct species, under the name of Buccinum acuminatum. Sometimes, after the occurrence of such an accident to a spiral shell, the form or sculpture of the whorls is entirely altered: they often become ventricose and smooth, instead of remaining thick and ribbed, as in the common state of the shell; and this change of form has even occasioned shells under such circumstances to be regarded as distinct species. As an instance of this I may refer to Cingula alba of Dr. Fleming, founded on specimens of Turbo parvus of Montagu, which had been injured in their growth. In Mr. Turner's collection there is a specimen of Terebra maculata, which had sustained an injury when about an inch and a half in length: the whorls beyond this injury are rounded and elevated near the suture, and are destitute of the posterior groove. In this specimen the colouring also is altered, for instead of being spotted, the irregular volutions are marked only with two narrow posterior spiral bands.

A distortion or change of form, caused by a fracture or other accident, is sometimes overcome, as the animal increases in size and recovers its strength. Thus a specimen of Strombus bituberculatus in my collection, which had met with an accident in its young state, has the five upper whorls sharply keeled and nodulous, as in the ordinary state of the shell, but the volutions formed after the accident turn more obliquely down the axis, and thus their anterior part becomes more exposed, leaving a deep narrow groove on the suture. The first half-whorl that succeeds the fracture is rounded and distinctly tubercular; after which the shell continues rounded, but quite smooth for a whorl and a half; when it again becomes slightly tubercular, and at length keeled and tubercular, the last whorl exactly resembling the last whorl of the normal shell. The collection of Mr. Lincolne, of Highbury, contains a specimen of Cassis rufa in a very similar state.

The shape of attached shells depends greatly on the form of the bodies to which they are applied; and this is a circumstance that has been generally overlooked by conchologists. It strongly affects most shells that are immediately and permanently attached, such as the Chamæ and Ostreæ, which completely assume the form of the substances on which they grow.* Thus the Chamæ and Spondyli attached

* Of the genus Chama, Mr. Broderip says:—"These shells appear to be subject to every change of shape, and often of colour, that the accidents of their position may bring upon them. Their shape is usually determined by the body to which they are fixed; the development of the foliated laminæ which form their general characteristic is affected by their situation;

to the plane surface of mother-of-pearl shells have always a flat side, whilst those which are adherent to coral and to other uneven surfaces are variously and irregularly shaped. The oysters which are attached to the branches of mangrove trees have a central convex rib, modelled on the shape of the branch, from which the plaits of the shell radiate; while the specimens of the same species fixed to the trunk are destitute of any such peculiarity. In the collection of Mr. Adamson, of Newcastle, there is a curious specimen of a common oyster found in the Frith of Forth attached to a species of Pecten; on the latter there also grew three corallines, surrounding the oyster, which have formed in its circumference three deep notches, giving it the form of an ace of clubs. The same changes may be observed to take place in the Anomiæ, which are attached by the intervention of a ligamentous band; thus the species called Anomia squamula is founded on young shells of the common A. ephippium attached to flat surfaces; whilst A. cymbiformis is characterized from small specimens of the same shell attached to the cylindrical spines of sea eggs, or to the stems of seaweeds.

A similar influence is also observable in such free univalve shells as have a widely expanded aperture, and an animal provided with a large foot, by means of which they remain for a considerable length of time adherent in the same situation. When a Patella or a Crepidula has attached itself to the flat surface of a rock or the leaf of a large Fucus, the base of its shell is flat, and its mouth roundish; when it adheres to a concave surface, such as the cavity of an old shell, the base becomes flattened, and convex internally; and when it fixes itself on the rounded stalk of a Fucus, the sides become compressed so as in some measure to clasp the stem, and the lateral portions of the base project beyond the front and hinder parts, to such an extent that when placed on a flat surface it rocks backwards and forwards. Several nominal species of these and allied genera depend on variations in the shape of the shell caused by the adhesion of the animal to surfaces of different forms; thus the Patella pellucida of Montagu is synonymous with the P. cærulea of the same author, the

and their colour, most probably, by the food and by their greater or less exposure to light. The Chama that has lived in deep and placid water will generally be found with its foliations in the highest degree of luxuriancy, while those of the individual which has borne the buffeting of a comparatively shallow and turbulent sea will be poor and stunted."—*Zool. Trans. Lond.* i. 301.

former having been founded on specimens taken from cavities in the root, and the latter on individuals obtained from the flattened frond of the Fucus on which the species usually takes up its abode: it is, indeed, by no means rare to find specimens in which the animal has moved from one of these positions to the other, and in such cases the apex of the shell represents P. cærulea and the base P. pellucida, or *vice versâ*. The same change takes place with regard to P. miniata and P. compressa. I have in my collection a specimen of this latter shell which is P. miniata at the top, it having in its youth lived on the frond of a large Cape Fucus; it afterwards removed to the stem, and became compressed, and consequently is in this part the P. compressa; but by some accident it was again induced to change its situation, and, removing to a flat surface, the edge of the mouth expanded, and it became a second time P. miniata, or perhaps what may be called by some authors P. saccharina, as this also appears to be a conical variety of the same species. Lamarck has described a similar specimen; and Mr. Sowerby, in his Genera of Shells, has figured an example of this species, showing the two states. In like manner the Crepidula porcellana, when applied to a flat surface, has an expanded base and a flattened inner lip; but when adherent to a convex body, such as the stem of the sea-weed, or (as frequently happens) to the back of another shell of the same species, the animal being pressed into the cavity, the inner lip becomes concave, and the sides of the aperture are contracted: in this state the shell is called by most authors C. fornicata.

When the shells of this family are adherent to irregular surfaces, they adapt their margins to the inequalities with which they meet. I have several specimens of Patella from the coast of Devonshire, having one or more processes on their sides, which fitted into holes in the rock to which I found them attached; and such changes are the more remarkable, as some specimens are seen constantly moving from place to place, whilst others appear to remain for a long time fixed in one spot, and even those that are thus stationary in the young state constantly elevate the margins of their shells when the tide is low. I have also a specimen of Siphonaria gigas exhibiting in a great degree a similar adaptation of its edges to the form of the rock on which it grew.

The substances to which attached shells become adherent, besides altering their general form, often change the character of their surfaces; thus, when fixed to ribbed shells,

like the Pectines, Cardia, &c., they are frequently variously ribbed, a circumstance which often takes place in the Common Anomiæ; and if attached to a Dolium, as in a specimen in the collection belonging to Mrs. Mauger, they even exhibit on their own surface the alternate broad and narrow ribs of that shell. In specimens of Crepidula adunca attached to Trochus doliarius (and inhabiting the same locality, they are not unfrequently so attached), the convex part of the former is marked with the ribs of the latter. Shells which are ribbed from this cause are, however, easily distinguishable from those which are naturally ribbed, the ribs in the former generally extending across or along the shell, and not radiating from its apex or nucleus, as in all shells the natural character of which is to be ribbed. In those which adhere to ribbed shells by the foot of their animal (as in most of the univalves), and are therefore capable of being moved from place to place, the young animal may have lived on a smooth surface, and have had a smooth shell; and may have moved, during its growth, to a ribbed body, producing ribs on the latter formed part of its shell, or *vice versâ*. In a specimen of Crepidula adunca, for example, in the British Museum, the upper half of the shell is smooth, and the lower half ribbed; and I have seen specimens, on the contrary, in which the apex was ribbed and the base smooth. This change of form has, however, misled some conchologists, for Dr. Bronn, of Heidelberg, has founded a genus under the name of Brocchia, on a specimen of Capulus, which had acquired a ribbed surface in consequence of having been attached to a Pecten or to some other radiated shell.

These alterations of form and surface are always most distinct in univalves and in the upper valve of bivalves. In the latter case, the edges of the upper valve being produced beyond those of the under, they are immediately moulded on the surface of the substance to which the shell is attached, whilst the under valve simply covers it over. This is well illustrated in the unique specimen of Hinnites gigantea in the collection of the British Museum, which must have been attached to some marine body having a Serpula growing upon it. There is merely an irregular convexity in the inner part of the under valve, but on the outer surface of the free valve is to be observed a representation of the whole form, and of almost the entire surface of the Serpula, in consequence of the edge of that valve, during each deposition of shelly matter, having rested on the worm-shell. In the collection of Mr. Lincolne is a specimen of an oyster

which, having been attached to a plank covered by a number of Balani and Serpulæ, has the upper valve marked with prominences, exactly agreeing in shape with the substances concealed beneath the under one. The edges of the valves of Barnacles being very closely affixed to the surface of the substances to which they are attached, it appears that they not only assume the form of the larger prominences, such as the ribs and spines of a shell, but also the most minute differences of its surface. A Barnacle in my collection, which had been fixed to a Scallop (Pecten suborbicularis), has not only the ribs of the latter marked across its valves, but the whole surface of the prominent part of the valves is covered in addition with minute rugosities, produced by the small projecting scales which cover the surface of the ribs of the Pecten, whilst the articulating portion of the valves is smooth, as in the common state of the species. In another similarly ribbed specimen the articulating portions are also ribbed like the rest of the valves; and in a third, which was found on a piece of roughly planed and loosely textured wood, the surface of the valves bears an exact resemblance to the grain of the wood on which the specimen was attached.

The thickness, the roughness, and the smoothness of the surfaces of shells appear to depend, in a great measure, on the stillness or agitated state of the water which they inhabit. The species of our own coast afford abundant instances of this: the shells of Buccinum undatum and B. striatum of Pennant have no other difference than that the one has been formed in rough water, and is consequently thick, solid and heavy; and the other in the still water of harbours, where it becomes light, smooth and often coloured. In the same way the specimens of Purpura lapillus, which inhabit sheltered situations, are covered with small arched scales, whilst those found in exposed places are thick and rugose. Lamarck, not being aware of this circumstance, considered the specimens in the first state as a distinct species, which he named Purpura imbricata. The English shells of the genus Pinna (and doubtless the foreign ones also) offer the same variations, which have given rise to similar subdivisions of species. Shells which have branching or expanded varices, like the Murices, are also much influenced by these circumstances; and hence many mere varieties, arising from local causes, have been considered as distinct species. Thus Murex angulifer is merely a Murex ramosus with simple varices; and Murex erinaceus, M. torosus, M. subcarinatus, M. cinguliferus, M. tarentinus and M.

polygonus of Lamarck, are all varieties of one species.* Murex magellanicus, when found in smooth water, is covered with large acute foliaceous expansions; but the same shell living in rough seas is without any such expansions, and only cancellately ribbed. In such situations it seldom grows to a large size; but when it does so, it becomes very solid, and loses almost all appearance of cancellation. Triton maculosus is very widely spread over the ocean in different temperatures and different kinds of seas; it consequently offers a multitude of varieties both in size and surface, all gradually passing into each other, and most probably produced by the operation of the foregoing causes. Indeed, a vast number of merely nominal species have been formed from the habit, too prevalent among conchologists, of describing from single specimens, or even from several individuals brought from the same locality, which would never have been considered as distinct had collectors kept in their cabinets a series of specimens found under different circumstances, and studied, on the coasts where they are found, the variations which shells undergo.

Those shells which are attached to rocks, either immediately by their outer surface, or by the intervention of a beard, are most acted on by these causes: thus the Anomiæ found in protected places are thin and transparent, while those which inhabit exposed situations are thick and nearly as opaque as the shell of an oyster; and the under valves of the Craniæ which are affixed to the branches of coral are very thick and solid, while those that adhere to the Pinnæ and other flat shells are so thin as to have been overlooked by conchologists, who have repeatedly described their upper valve as a species of Patella.

Boring shells are greatly influenced in regard to their size, thickness, and form by the hardness or softness of the rock in which they are found: thus the specimens of Pholas dactylus found in the soft rock of Salcombe, are large and thin, and are covered with beautiful, regular, arched scales; while those found in the hard rock are small, irregular, thick, with a very wide anterior gape and large dorsal valves, and closely wrinkled externally, but almost or entirely destitute of scales: and the Saxicavæ, found in hard limestone, are often curved and otherwise distorted, in order to avoid the harder parts of the rock during the process of boring.

* "Varietates conchyliorum exclusi numerosissimas, Murices tamen frondosos admisi, quamvis inter se nimis affines."—Linnæus, *Syst. Nat.* 1216.

Land shells are much influenced, as regards their size, by the temperature, altitude, and abundance of food, of the country in which they are found. Specimens of Helix arbustorum from the Swiss Alps, are not one half the size of those of the neighbourhood of London; the shells of Helix nemoralis and H. hortensis, found in the last-named locality, are not above two-thirds the size of those which occur in Portugal and in the south of France; and there is so much difference in size between individuals of Bulimus rosaceus found on the coast and on the mountains of Chili, that the latter have been described as a distinct species under the name of Bulimus chilensis. There would be no difficulty in multiplying examples of the same kind.

It is not so easy to determine the influence of climate on marine shells, although there is little doubt, from the great differences of size observable between specimens of the same species, brought from different localities, that it actually exerts considerable power. Indeed, I have been enabled to mark this difference in some of the shells found on our own coast. The specimens of Littorina petræa found on rocks with a southern exposure near Torquay, are larger than almost any others which I have met with in England; but the largest of this species that I have seen, occur on the part of the Breakwater at Plymouth next the sea, where they are much exposed to the sun. The latter are twice the size of any that I found on the northern face of that magnificent structure.

The colouring of many shells evidently depends on the degree of exposure to light, air, heat, and the action of the waves to which they may have been subjected. Thus, among the Patellæ and Crepidulæ, those which are attached to the stems of Fuci or other round bodies, and are thus exposed on all sides, are of a dull colour, or nearly colourless. This is well exhibited in the specimen of Patella miniata before referred to, which had changed its place of attachment twice during its growth; the two portions of the shell formed while the animal was affixed to a flat substance being white, beautifully varied with bright red (the general colour of P. miniata), whilst the central portion of the shell is of a dirty yellow, with a few indistinct, reddish dots, like the ordinary specimens of P. compressa.* In like manner P. pellucida when obtained from the stems of Fuci is of a pale horn colour, whilst the same shell, on the leaves, is of a beautiful purple with longitudinal pale blue lines.

* Such exposed shells are very rarely bright coloured; but a specimen of Patella compressa formerly in the collection of the late Earl of Tankerville, but now in that of Mr. Lincolne, is coloured nearly as brightly as P. miniata.

The thinnest specimens of a species are generally the best coloured. The light certainly exerts considerable influence on the strength of colour, even in marine shells; and it appears to be owing to its modifying power that many Nassæ, Buccina, Naticæ, Cypræœ, and other littoral shells, have the back part much darker than the rest. This is particularly the case with Nassa glans, Natica castanea, and several Cowries, as Cypræa stolida, C. errones, and C. caurica, which have always an irregular bright bay spot on the back of the body volution.

The colour of shells is generally disposed in rays, streaks, or bands, arising from the nucleus and extending to the circumference; in the spiral shells the lines of colouring consequently follow the direction of the whorls. The rays vary greatly in size; they are sometimes interrupted, and they generally become wider as the shell grows larger.

These coloured bands are evidently deposited by glands placed on the margin of the mantle. Sometimes the action of the glands is interrupted, and the bands are broken. In a few shells this suspension of the action of the glands takes place at regular and very short intervals, in which case there is formed a chain-like band, as in Marginella catenata, certain Cones, and some other shells. In the Volutæ, Olivæ, Coni and some Cassides, the colouring often forms angular lines, so disposed, that the glands which deposit it seem to have receded from each other, and then again contracted together. Sometimes, as in Oliva tessellata, for example, these lines are broken into spots; but even in this species some specimens exhibit the spots united into angular lines.

In general the colour is situated on the outer coat of the shell. It is often deposited on the inner side of the outer layer, as in Strombus bituberculаris, and sometimes extends a little into the outer part of the middle layer; but I do not recollect to have ever seen it pervade the whole thickness of this coat. This circumstance leads me to believe that the colouring matter is generally deposited by the glands immediately after the deposition of the calcareous particles on the periostracum, and during the formation of the outer coat which, as will be seen hereafter, is always deposited before the two inner ones.*

This situation of the colouring matter explains the reason why many shells, such as the Olives and Cones, are darker when their outer coat is removed; this is particularly the

* Sometimes the colour coat is destroyed by age: thus in the old Cowries the colour is obliterated by a gaudy olivaceous coat.

case with Oliva utriculus, which is often sold in that state as a different shell. There is reason to believe that Lamarck was deceived by a specimen which had been so mutilated, and which he described as a distinct species, under the name of O. harpiformis.

The belts across the whorls of the Olivæ and Ancillariæ have the coloured matter deposited on their inner surface. In a few shells, the Oliva porphyria for example, some of the more distinct coloured lines even form raised ridges on the outer surface; and in some others the inner layer is darker than the outer. Thus in Oliva tessellata and O. lineolata, and some Cowries, the inner layer is purple; in O. spidula, brown; in Turbo chrysostomus and T. nicobaricus, bright golden; in Capulus hungaricus, in Strombus gigas, and in many others, pink: but it is generally much paler, and in the greater number of shells white or colourless.

Some brown shells, such as the Volutes, become white when touched with a hot iron: there was formerly in the Museum at Paris a specimen of a Melon, marked in this manner with close series of white spots. The purple colour of some shells is also changed under a similar treatment to dusky red; and it is by this process that the red spots are formed on the polished muscle-shells and uncoated Nutmeg Cowries, which are, or were, so abundant in the shops. A very curious effect is produced by ink on some purple shells, which I have seen only in individuals of that colour. On the receipt of the Cracherode collection of shells at the British Museum, my uncle, Dr. Gray, wrote on each of them with a pen and ink the number of the catalogue and the name of the species. In some instances, although the ink has been washed off, the name and number are still distinctly visible, forming an evenly raised letter as broad as the ink line, and slightly interrupted, as if by bubbles, in a few places. This is particularly visible in the specimen of Solen diphos, No. 186, in that collection. The effect, however, is not produced in all shells of this colour, nor even in some of the same natural genus which were written upon at the same time; but as I have observed it in a few other purple shells, and as I have not met with it in any of a different colour, I am inclined to think that the nature of the colouring matter may have some share in its production.

3. *The Structure of Shells.*

Shells exhibit, when examined, two very distinct kinds of structure: in the one case the calcareous particles of which

they are formed are crystallised, in the other they are granular. These differences in structure correspond with differences in their chemical character; the shells in which the lime is crystallised appearing to contain less animal matter than the others. The primary division of shells according to their structure consequently agrees with the division proposed by Mr. Hatchett, in his paper on their chemical composition; the porcellaneous shells of that distinguished chemist being crystalline, and the nacreous granular.

Shells of the crystalline structure are themselves of two very distinct kinds; the crystals being rhombic in some, and prismatic in others.*

Those of the rhombic crystalline structure exhibit, when broken, three distinct layers of calcareous matter. On examining fragments of most of the spiral univalves, there will be observed on two of the fractured sides of the cubic pieces into which they generally break, flat surfaces on the inner and outer edges, separated from each other by a shelving portion in the centre; and on the two intermediate broken sides shelving external and internal edges, connected by a flat central portion; these differences of surface being produced by the different position of the crystals of the different layers.

Each of the three layers, thus rendered obvious, is composed of very thin laminæ, placed side by side, as high as the thickness of the plate and perpendicular to its surface. When these laminæ are minutely examined, they will be found marked with obscure oblique lines; in the direction of which they separate, when broken, into long narrow rhombic crystals. The lines of cleavage in the succeeding laminæ are placed in contrary directions, so that when two of these plates united are examined under the microscope, the lines of cleavage appear to cross each other at right angles, whilst those of the alternate laminæ follow the same direction.

The laminæ of the outer and inner plates are always directed from the apex of the cone of which the shell is formed towards its mouth; in the spiral shells they consequently

* Woodward and Poli described the prismatic structure; and the Compte de Bournon, in his "Traité de Mineralogié," described the rhombic structure in the Strombus and Cypræa, but his work has been overlooked by all conchologists, and was not known to me until long after this paper was published. It is curious enough that it has not been referred to by any of the numerous persons who have written to me about these observations. The Compte de Bournon only considers the shell mineralogically, while I have referred to it physiologically, and in its living relation to the animal.

follow the direction of the spire. On the contrary, the laminæ of the plate situated between the other two, form concentric rings round the cone parallel with its base, and cross at right angles those of the inner and outer layer. This decussation of the laminæ of the plates, and of the crystals of the laminæ themselves, adds considerably to the strength of the shell, and accounts for the great difficulty that is found in breaking many shells of this structure, more especially the Cones and Olives, in which, however, nearly the whole of the strength resides in the outer whorl and in the spire.

A good illustration of this structure may be obtained by examining with a pocket-glass the fractured edge of a Cone, Olive, or other spiral shell, in which the extremities of the laminæ of the outer and inner plates, and the sides of those of the central layer, or the converse, will be observed, according to the direction of the fracture, the extremities of the laminæ showing the angles of the crystals, while their sides, when closely examined, will often exhibit the crystalline flakes. In order to observe the lines of cleavage, the best mode of proceeding is to bruise part of a shell with a hammer, and to examine the fragments moistened under a microscope, until one is discovered which exhibits two laminæ in conjunction. The plates and their structure are also well seen in the polished surfaces of shells which have been slit or ground down to exhibit the internal structure of their cavity. The relative thickness of the three plates varies in different species; but as far as I have yet examined, the central plate is generally rather the thickest, and the outer one the thinnest. The Italian cameo cutters appear to be aware of this structure, and avail themselves of it in cutting the cameos, the ground being always formed of the innermost layer of the three, which is also generally the most transparent.

The layers increase in thickness from their inner to their outer edge, each of them being formed by successive depositions of thin coats of animal and calcareous matter on its inner surface, until it acquires the proper thickness for the shell, the outermost edge of which is very thin, and has during the progress of the growth little calcareous matter, but gradually passes into the periostracum.

This accumulation of calcareous particles, deposited at various times and nevertheless forming the same crystals, is well illustrated in the prismatic crystalline shells. These are also evidently formed of several layers, which in some instances, as in the Pinnæ, are distinctly separate from each

other; if, however, the shell be cracked transversely to its layers, the crystals will be found continued across the line which separates them. An analogous structure exists in some minerals, the Hæmatite for instance, the balls of which appear to be formed of separate concentric coats, but nevertheless when they are broken exhibit the crystals radiating from the centre to the circumference without interruption.

The plates of which the rhombic crystalline shells are formed are deposited in succession, each gradually increasing in thickness as the shell enlarges, and undergoing no variation in this respect after the deposition of the succeeding coat has commenced. That the coats are deposited in regular succession, may be seen by examining the lip of any shell which has been taken whilst the animal was increasing its size. At this period the lip will be found gradually shelving and becoming thinner from the inner to the outer edge, the innermost part being formed of three, the next of two, and the outer and thinnest part, which is always the first formed, of only a single layer. This is best seen by making a section of the lip of a Strombus or a Cone along one of the spiral grooves, in which, if the polished edges be examined, the layers will be distinctly seen. When the animal is about to make its periodical stoppage of growth, the second, and afterwards the innermost layer is deposited up to the edge of the mouth, which is thus completed.

In the Olivæ, Ancillariæ, and some Volutæ, which have, at all periods of their growth, a polished surface (now known to be caused by their shell being more or less immersed in the large foot of the animal), the outer layer, although equally crystalline, is very thin. It is harder and much more compact than the others, and between it and the central layer, there is deposited an opaque, white, powdery film, which often causes it to break off in splintery flakes, while the rest of the shell separates into fragments, generally more or less cubical, their form depending, doubtless, on the rectangular disposition of the laminæ of which the plates are formed.

Some Olives, as Oliva utriculus, O. undatella, and O. acuminata, have an additional band, in structure and hardness resembling the outer coat, forming a belt over the latter, across the front of the whorls; and some Ancillariæ, as Ancillaria marginata have also a similar belt placed on the back of the volutions.

When the animals of many of the shells of this structure arrive at their full size, or when they form the successive mouths of their shells at their periodical stoppages of growth,

they deposit a considerable number of layers of shelly matter, either on the lip or on the pillar: these layers are formed of laminæ disposed in the same manner as those of the inner layer of the body of the shell, and, indeed, may be considered as repetitions of this part.

The animals of some genera, as for instance Cypræa, Ovula, Erato, and Marginella, deposit, at the same period, on the outside of their shells an additional coat covering the lip and back, which may also be considered as a continuation of the inner layer, since it agrees with this layer in the position of the laminæ: it changes its character, however, on becoming external, being harder, more compact, and often differently coloured. In all these cases the sides of the mantle of the adult animal are expanded into wing-like processes, which are reflected over the shell, and deposit this additional layer. In the Cypræa, Erato, and Ovula, in which the lobes of the mantle are large and nearly meet, there is left a differently coloured line at the place of their junction, which, on account of the left lobe of the mantle being usually the largest, is generally situated on the right side of the back, and is called the dorsal line: this line is not observed on the Marginellæ, the lobes of the mantle being in them less developed, and leaving a broad uncovered space on the back.

It is probable that the polished coat of the Struthiolaria oblita is formed in the same manner, but the animal of this shell has not been examined. From the reflected form of the lip, however, in other species of that genus, and from the edges of the mantle in the other genera of the family of Strombidæ (to which Struthiolaria evidently belongs), becoming developed when the animal attains its full growth, as is proved by the expansion of the lips of the Strombi and the lobed form of those of the Pteroceræ and Rostellariæ, it is easy to suppose that its lobes may even become completely reflected.

The species of Cymbium, when fully grown, or under particular circumstances, are often covered externally with an additional glazed coat, which is apparently deposited by the foot; as the animals of these shells are not provided with large lobes to their mantle. This coat being deposited, over the periostracum, is liable to be broken off.

There is deposited on the sides, and more especially in the posterior part, of the cavities of the upper whorls of many of the spiral univalves, a transparent calcareous concretion, which lines, and more or less fills up the cavity. This deposit may be observed lining the cavity of the upper

whorls of Mitra episcopalis, Triton pileare, Cassis glauca, Voluta hebræa, and several other shells. In some, which have an elongated acute spire, as in the various species of Fasciolaria, and in the turreted shells, such as the Terebræ, Cerithia, and Turitellæ, it entirely fills the cavity of the tips, which, from their small size and original thinness, would otherwise have been liable to be broken. Its deposition is not confined to adult shells, for I have observed it filling the cavity of the upper volutions, and lining the succeeding ones, in a slit specimen of a young Strombus gigas in the possession of Mrs. J. P. Atkins, to whom I take this opportunity of expressing my thanks for her kindness and liberality in allowing me to examine the numerous dissected shells in her collection.

In those Volutes which retain the nucleus (or that form which the shell has when first hatched), that part which was originally very thin and brittle, is speedily filled up with the deposit in question. In fact, all shells whose spires are exposed, and, being thin in their young state, would be liable to be broken off by the action of the sea, have that part strengthened by the internal deposition of calcareous matter.

The distinction between these and the decollated shells, such as Bulimus decollatus, Cerithium decollatum, &c., is, that in the latter the animal, instead of lining the upper whorls with an internal coat, suddenly withdraws its body from them and forms behind its extremity a concave septum; and the vital communication between the body and the apex of the shell being thus cut off, the latter part decays, in the manner of a dead shell, and falls off in particles.*

The greatest development of the deposit mentioned above is to be observed in the genus Magilus, in which the young shell is very thin, shaped like a Purpura and of a crystalline texture; but when the animal has attained its full size, and has formed for itself a lodgment in a coral, the greater part of the cavity of its shell is filled with a glassy substance, leaving only a small conical space for the reception of its body: layer after layer of this substance are then deposited in rapid succession, in order to keep the body of the animal on a level with the top of the growing coral in which it is buried, until its shell is almost lost in the quantity of glassy matter subsequently formed.

* M. De Blainville refers the decollation of the spire to the inner surface of the cavity of the shell becoming filled with a very brittle glassy deposit.

The shells of the prismatic crystalline structure exhibit, when broken, a quantity of short fibres perpendicular to the surface: when examined, these are found to be mostly hexagonal prisms, with a few smaller polyhedral prisms interposed. This structure, which has been repeatedly described, is to be observed in the tube of the large Teredo from Sumatra, in the vitreous deposit of Magilus, and in many bivalves, especially those which belong to the families of Mytilidæ and Aviculidæ, as the Pinnæ, Mother-of-pearl shells, &c.; and it may likewise often be seen in fossil shells, such as the Inoceramus, fragments of which, exhibiting this structure, are frequently found imbedded in flints.

On the other hand shells of the concretionary structure exhibit, when broken, a nearly uniform texture: they separate, when heated, into numerous thicker or thinner laminæ; and when digested in weak muriatic acid the lime is dissolved, leaving a great number of thin plates of animal matter, which retain the original shape of the shell. In general the plates of which these shells are composed are very thin, and closely applied to each other, forming by their union a hard and compact texture.

The pearly or iridescent lustre appears to be confined to shells of this texture, in which it is very general; a circumstance which induces me to believe that this lustre depends in a great measure on the thinness and number of the laminæ of which the shell is formed.*

This variety of structure is found to constitute the whole shell of the Anomiæ and Placunæ; and to form the inner coat of those shells which have pearly insides, as the Turbines, Haliotides, Uniones, &c., as well as the laminar portion of the Pinnæ and Mother-of-pearl shells.

When such shells disintegrate, they separate into very numerous thin lamellar scales of a pearly grey colour and silvery lustre. The Chinese are aware of this circumstance, and use the particles of the disintegrated Placunæ as silver in their water-colour drawings. I have myself used some of this silvery powder, brought to England by Mr. Reeves, for the same purpose, in colouring the figures of fish with good effect: it is not quite so brilliant as the powdered leaf metal, but it has the advantage of not changing colour by exposure.

In some shells of this structure the layers are thicker, and the animal matter is deposited in larger quantities, giving

* The iridescence of the Turbinella prismatica and of Bulimus cactivorus appears to depend upon the texture of the periostracum.

the shell a foliaceous appearance. In these the calcareous particles are large, opaque, white, and earthy, like chalk. This is well exhibited in the common oyster; and is also found, not so distinctly developed, in the Pectines, and on the outer surface of those shells which are internally pearly, such as the Haliotides, Turbines, &c. The animal matter between the laminæ is sometimes very unequally deposited: it is found forming large brown spots in the pearly coat of many of the Haliotides, especially in the Haliotis midæ, and H. splendens, in which these spots produce beautiful variations in the colouring and pearliness of the shell.

In many of the fresh-water bivalves there is deposited between the layers of the shell a lamina of animal matter, similar to the periostracum. In the genera Etheria and Mulleria, such a coat is deposited between nearly all the layers, giving them a very peculiar olive-green colour, and having minute dots on its surface.* The shells in question appear to be extremely liable to be eroded by the water, and these successive depositions of animal matter enable them to offer a new layer of periostracum to protect each succeeding plate, as the one above it gives way to the destructive influence of the medium in which they reside. A similar deposit of animal matter is also often found forming green stains in the pearly inner coat of the various species of Uniones, and it sometimes protects from the action of the water the inner part of the umbones of shells which have been eroded. In the upper valve of Ostrea cornucopiæ, I have observed the thick inner layer to be rather prismatic, and the outer part of the laminæ to be separated by layers of periostracum.

In some shells of this kind there are left between the plates larger or smaller spaces, which are generally found filled with water. These spaces are sometimes met with in the common oyster, and they occur not unfrequently in a large Spondylus, which is known to the dealers on this account, by the name of the Water Spondylus. In the latter shell it is not unusual to find these cavities, which are sometimes of a large size, in both the valves, recurring one on the top of another, and giving the valve, when cut through, the appearance of a chambered shell; but having no siphon passing from one septum to the other. There can be little doubt that these laminæ, the concave plates at the end of

* Mr. Goulding observes that the cavity of the Mangrove oyster is often disfigured with calcareous blackened blisters, which are laid by the mantle over any extraneous bodies which happen to intrude within the shell.—*Zool. Journ.* iii. 542.

turreted shells, and the septa of the regularly chambered shells, are all deposited in the same manner, the body representing the model on which they are formed. But it is not so easy to understand why such cavities should be left in these shells, especially in the upper valves, as it is to account for the existence of the analogous structure in turreted and chambered shells, the flat form of their valves enabling the animals of the former, as we might suppose, to extend the diameter of the existing cavity, when larger space was required for their accommodation without constructing one altogether new. In the Etheriæ, cavities in the form of small vesicles, or very thin bladders, are also left between the plates. The cavities in the Ostreæ, Spondyli and Etheriæ, are, I have reason to believe, filled with water when the animals are alive; and this also appears to be the case, from Mr. George Bennett's account, with the chambers of the Nautilus; but the water soon evaporates through the pores of the shell, if kept in a dry place. I have never observed this peculiarity except in those bivalve shells which are immediately attached by their outer surface to other bodies.

Many shells are composed entirely either of the rhombic crystalline or of the concretionary structure; but I know only of a single instance (and that occurs in the tube of a shell) in which the whole mass affects the prismatic crystalline structure. In all other shells of this latter texture, the inner and front part, which is occupied by the body of the animal, is always covered with a coat of the laminar concretionary texture.

4. *On the Power possessed by Mollusca of dissolving Shells, Rocks, &c.*

It has been generally believed, and indeed sometimes most positively asserted, that Molluscous animals do not possess the power of re-absorbing the matter of their shells when once deposited. The following observations, I think, will distinctly prove that this assertion is quite unsupported by fact.

If a cone, an olive, or any shell whose last whorl nearly envelopes and protects the rest, and whose cavity is much compressed, allowing only a small space for the convolutions of the body of the animal, be slit down, either from the apex to the front of the axis, or across the body volution, at a little distance before the suture, it will be observed that all the septa between the different whorls are extremely

thin and transparent; and when these septa are minutely examined, they will be found to consist of only a single one of the three plates of which all such shells are originally composed, which plate will be seen to agree in structure with the inner one of the three. On tracing these septa to the outer whorl it will be observed that every part of them, during the various stages of growth of the shell, has been once a part of the outer whorl; and since we know from experience that the outer whorls of the young Olive and young Cone are as thick, in proportion to their size, as those of the adult, there is little reason to doubt that each of these septa was originally formed of three plates, in the same manner as the other parts of the shell. That this was actually the case, and that the part remaining is the continuation of the inner plate, the other two plates having been removed by absorption, may be proved by the fact that the other two layers of the same volutions are distinctly visible on the exposed part of the spire, and on the front part near the pillar, while they are deficient only on the thin part of the septa; and if the outer half of the penultimate whorl, or rather the half-whorl just within the mouth, be examined, the two outer layers will be found to be there, only in part absorbed, leaving a shelving edge directed towards the cavity of the shell.*

A still stronger instance of the absorption of the septa may be observed in the shells formed by some of the land Mollusca, as, for instance, the Auriculidæ. In the young shells of this family the septa which separate the whorls are incomplete, and twine nearly parallel to each other. As the shells increase in size, the later formed septa become much more oblique and broader, and at length completely separate the cavities of the whorls. When, however, the animals of many of the species, especially those of the Melampi, approach maturity, the whole of the septa except the outer half of the penultimate volution are absorbed, leaving a simple cavity in the hinder part of the shell. On further examining the remains of the septum, it will be found that

* It is probable that some Bernard crabs have also the faculty of dissolving shell, for it is not unusual to find the long fusiform shells (such as Fusus, Fasciolaria and Turbinella), which are inhabited by these animals, with the inner lip and great part of the pillar on the inside of the mouth destroyed, so as to render the aperture much larger than usual. I have never seen this erosion except in dead shells which had been inhabited by Hermit crabs; but it does not occur in all that are so tenanted, for I have also observed these animals occupying the shells of Fusi, &c., in which the lip was in its usual state.

the absorption has taken place on the outer side, as is proved by the surface shelving down to form an acute edge on its inner side.

A similar absorption may be observed in the inner whorls of the Harpa articulata; but it is in this case confined to the central part of the septa, and all the coats are partially dissolved, so as to leave a slit between the cavities of the different whorls. An absorption of the upper septum also takes place in some of the Neritinæ, as the Neritina fluviatilis; and it was on a character derived from this circumstance that M. de Montfort established the latter shell as a genus under the name of Theodoxus.

These facts distinctly show, that as the animal enlarges the mouth of its shell, it absorbs in a greater or less degree the substance of the inner whorls. This process of absorption, besides furnishing the animal with calcareous matter towards the enlargement of its shell, gives more space for the lodgment of the body, and renders the shell far lighter to carry; and these advantages are gained without in the slightest degree detracting from its strength, as the outer whorl and spire, which are alone exposed in shells of this form, remain at least as thick as in most other shells.

In many other univalves the animal, before depositing the laminæ which form the inner part of the mouth, absorbs the outer layer of the penultimate whorl, as is evidenced by the ridge with which that part is often surrounded. This is particularly the case in the various species of Turbines, as in Turbo coronatus, T. smaragdus, T. sarmaticus, and in some Fusi, as Fusus despectus. But it is most distinct in the Purpuræ, where the Lamarckian character of the genus depends upon this absorption, which causes the concave flatness of the inner lip. In the Murices, and other shells which have spines or branching appendages on the front of the whorls, the site of which appendages the succeeding whorls must overlap, these processes are generally absorbed by the animal before it produces the inner lip over their base, as their length would otherwise offer an obstacle to the regular progress of the shell. This absorption of the outer part of the last whorl but one, and of the spines, is evidently effected by the edge of the mantle. In specimens taken while the process is going on there may be observed a notch, formed by this means, in the base of the spines or processes, the completion of which causes them eventually to separate from the shell. A similar effect is produced on a new species of Sun Trochus, Imperator guilfordiæ, where the keels of the whorls are furnished with a central series of spines,

which are removed before the mouth of the shell is continued.

In some shells, however, which have only short processes, as in the variety of the Pyrula bucephala with two rows of spines, the front rows are not absorbed, the inner lip being deposited of such a thickness as to cover them. A similar circumstance may be observed in a monstrous variety of Strombus pugilis, with two rows of spines, of which there is a specimen in the British Museum.

In the young state of the Fissurellæ, the hole by which the fæces pass out of the shell is placed a little in front of its recurved and spiral apex: in this state it has been formed into a genus under the names of Rimula and Puncturella. But as the animal grows the hole enlarges in size backwards, and the true apex being absorbed, the hole appears in the adult shell to be placed on the tip, and in some species even to extend behind it.

The animals of many species absorb parts of their shell at regular periods: thus the Tritons, which at each of the periodical interruptions of their growth form a thickened edge to their lips, when they again commence enlarging their shells, generally absorb this thickening both as regards that part which had been deposited on the pillar, and that which formed the ribs and teeth of the outer lip; for on examining the cavity of any of these shells it will be found quite smooth and free from interruption. Such an absorption does not, however, take place in some of the larger Cassides, and in the genus Persona, in which the thickening of the former lips remains after the shell has enlarged in size, and forms prominent bands on the parietes of its cavity. But a similar periodical deposition and absorption of the thickening of the outer lip takes place in many of the land shells, as the Helices and Bulimi; in most of which there is formed, at every interruption of their growth, an internal rib, just within the edge of the mouth, which is removed when the animal again begins to increase its shell. This is particularly visible in the genus Scarabus, where the interruptions are regularly periodical, each period of growth occupying half a whorl, as in the Ranellæ.

Mollusca not only have the power of absorbing their own shells, but they also possess the faculty of forming cavities in those of other animals. When a specimen of Pileopsis attaches itself to the surface of a shell, it generally leaves in the place of its attachment a depression of its own size, and furnished with a horse-shoe-shaped ridge: such cavities are sometimes formed even in other specimens of their own

species. It appears moreover to be of little importance how great may be the hardness, or what may be the structure, of the shell on which they fix; all yielding with equal readiness to their absorbing powers. It is not unusual to find holes thus produced nearly a quarter of an inch in depth in the very hard external coat of the larger Turbines; and similar depressions are found in Purpuræ, Strombi, Fissurellæ, Chitones, Patellæ, &c.

The animals of Siphonaria, Patella, and an allied genus (Lottia), which appears to be peculiar to the coast of South America, have the same faculty, but in a less degree, and the cavities formed by them are destitute of the horse-shoe-shaped ridge. The depressions produced by the Siphonaria and the Chitons have, however, an unequal groove round their margin, which is largest and deepest on one side, occasioned probably by the shell being generally raised on the opposite side to admit of the access of air to the branchiæ. The Patella cochlea is often found at the Cape of Good Hope, where it lives almost exclusively attached to a large species of the same genus, on the surface of which it forms a flat disk, exactly the size of its mouth. To form these flat disks (of which there are so generally two, one on each side of the apex of the large Patella, as almost to form a character of the species), and to assist in the increase of its size, the animal appears also to absorb any coralline or other similar substance with which the larger shells are abundantly covered. The common Patella of our own coast, when long adherent to another shell of its own species, to chalk, or to old red sandstone or limestone, also forms for itself a deep cavity of the same shape as its shell, and evidently produced by the dissolution of the surface to which it is affixed.

The animals of the several species of Vermetus, especially of that called by Daudin Spiroglyphus, have the faculty of producing by absorption a groove in the surface of many very hard shells, such as the Trochi, Haliotides, and Fissurellæ; which groove they cover with a calcareous deposit, and thus form it into a tube. The history of Spiroglyphus is altogether peculiar: the young animal, when first hatched, is covered with an ovate regular spiral shell, consisting of a whorl and a half, and in appearance very like the young shell of Magilus, with which, indeed, its affinity is very striking; it soon attaches itself to the surface of a shell, in which it commences the formation of a canal, narrow and shallow in the first instance, but becoming deeper and wider as the animal increases in size. Both the canal and its shelly covering retain for some time the regular discoidal spiral form,

and the whorls are sometimes so closely impressed on each other, that the animal actually absorbs part of the tube which it had previously deposited, in order to make room for its new whorl. In one instance which has fallen under my observation, it had left only a very thin transparent plate between itself and the cavity of the tube. When, however, the animal has nearly attained its full size the shell assumes an irregular form, and is sometimes extended into a straight line, and at others closely twisted over its former shell, which, under such circumstances, it often absorbs. It is not uncommon to find several young animals of this genus burying themselves in the tube of an adult shell.

These unequivocal instances of the power of the Mollusca to dissolve their own shells, and to make holes in the shells of other animals without the exertion of any mechanical force, but by simply applying their mantle or foot to the part to be dissolved, afford strong grounds for believing that the holes formed by the regular boring Mollusca, such as the Pholades, Petricolæ, Venerupes, and Lithodomi, in shells and calcareous rock, are produced in a similar manner; and this belief is strengthened by the following considerations:

1st. That the animals of most of the boring shells are furnished, like those of which I have just been speaking, with a large foot, more or less expanded at the end.

2ndly. That the holes bored by some of the Petricolæ and Gastrochænæ are compressed, and so exactly fit the shell, that it would be impossible for the latter to rotate on its axis in such a manner as to use the asperities of its surface for the purpose of rasping, as some conchologists have supposed. I have also seen specimens of Pholas pusillus, the back valves of which were so much distorted, as to demonstrate the impracticability of such a process, a projecting part of the back having evidently been fitted into a cavity on one side of their cell; yet these Pholades appeared to have enlarged subsequently to the distortion having taken place. Those of the Barnacles which bore, such as the genera Conchotrya and Brismeus (and probably Lithotrya), form an oblong compressed hole, of the exact size of their shells. Specimens of Brismeus in my collection are placed on the side of an oyster-shell, in which they have destroyed part of two or three plates to form such a cavity; but although the shells of these boring Cirrhipedes are furnished with raised lamellæ, the projections are placed across the valves in such a manner that no motion that could be given to them would enable them to rasp a hole.

3rdly. That all the boring shells are covered with a peri-

ostracum, which is thin in the Teredines, Pholades, Laseæ, &c., thick in the Lithodomi, and which, if the animals used the outer surface of the shell as a means of boring, must be very speedily rubbed off. Such a fact would be readily observed, as this part is never renewed after having once been destroyed; which is easily understood when we consider, that it can only be formed on the edge of the shell before the deposition of the shelly matter has advanced beyond it.

4thly. That although the shells of Teredines, Pholades, some Petricolæ, &c., are covered with short spines and striæ by means of which they might be supposed capable of rasping stones, other boring shells, such as the Laseæ and Lithophagi, are smooth.

5thly. That I have not observed shells of this kind to bore into any other substances (wood excepted,) than shells, calcareous rocks, clay, marl, chalk, limestone, and sandstone united by a calcareous cement; nor do such shells, as far as I have seen on the coast of Devon, attack the latter rock, except when it has lain a long time under the sea, and become as soft as clay. Colonel Montagu states that he has seen specimens of Gastrochæna which had bored into fluor-spar and granite; but an examination of his specimens in the British Museum proves that what he considered as fluor-spar are merely crystals of carbonate of lime; and although the shell is not uncommon on the coast of Cornwall and Guernsey, I have never seen it produce the slightest impression on the granite rock, even in its disintegrated state. Instead of attempting this, the animal changes its habits, and generally chooses a slight crack in the granite rock, in which it forms for itself, like some of the fossil species of the genus called Fistulana by Lamarck, a calcareous case, partly constructed of such fragments of shells or stones as may be thrown within its reach. The granite, indeed, appears completely to resist all the dissolving powers of the Mollusca. Thus in some structures, as the Plymouth Breakwater, for instance, in which limestone and granite are employed together, and placed side by side, the Patellæ form their rounded holes in the former; while they do not in the slightest degree alter the surface of the latter, except in general by clearing off any calcareous substance which may have previously grown upon it. I have one specimen beautifully illustrating this latter fact, a young Patella having affixed itself to the shelly base remaining from a Barnacle, in which it has dissolved only the part beneath its foot, leaving the rest forming a ring around its shell.

Many of the boring Mollusca, especially the Lithodomi and Petricolæ, cover the hinder part of their shells with a calcareous coat, which is often of a spongy texture, and differs from the shell in internal structure. This is probably the dissolved part of the rock again deposited. Many also of these animals, as the Gastrochænæ, Clavagellæ, and Teredines, secrete constantly, and others, as the Lithodomi, under particular circumstances, a calcareous deposition, with which they line the inner surface of their holes.

The determination of the existence of this power of dissolving shell and calcareous matter does not, however, remove the difficulty with regard to those shells which bore into wood; although it is not impossible that this substance may also be dissolved by the same means. And this appears to me the more probable, as, although there are some species of Pholades, such as Pholas pusillus and P. rudis, which I have never seen in any other substance, I have found others, such as P. dactylus and P. candidus, indiscriminately in chalk, marl, limestone, red sandstone, and wood; and it is difficult to suppose that these species adopt different means of boring when employed in penetrating the latter substance.

Possessing this power of absorbing their own shells, the shells of other Mollusca, and calcareous rocks, it is remarkable that these animals do not exert it for the purpose of removing extraneous obstacles which may oppose their progress in the formation of their shells. In the collection in the British Museum is a specimen of Pyrula bezoar which appears to have grown with perfect regularity until the formation of its last half-whorl, which is thrown considerably more than half an inch out of its proper position by a group of Barnacles. These shells had probably attached themselves to the back of the Pyrula at an earlier stage, and, as the latter increased in size, at length filled the place that should have been occupied by the inner lip, which, on meeting with this interruption, diverged from its course, and was thrown over the Barnacles. Had the shell not been taken until a later period, there can be little doubt that the animal would have at length destroyed the Barnacles, and completely hidden them from view, by continuing the whorl entirely over them; although it would appear that it had not the power to remove them by absorption while they retained their vitality. In the same collection there is also a specimen of Strombus luhuanus the spire of which has been much distorted in consequence of the temporary attachment of some parasitic shell, which subsequently became loose and has been detached.

In the collection of my friend Mrs. Mauger is a specimen of Helix aspersa, showing a similar deformity arising from the same cause; but in this case the obstruction has been produced by a young shell of the same species. The young specimen is attached to the spire, to which it had doubtless fixed itself during the dry season; and not awaking from its torpor so early as its older companion, the latter, when it commenced increasing the size of its shell, threw its new whorl partly over the smaller individual, which was thus inclosed in a prison formed by its own shell. In this instance the form of the larger specimen is not much altered; but about one half of the young shell projects above the spire.

In like manner the Cowries, and other shells which have an additional coat deposited on their back by the enlarged lobes of the mantle, on arriving at the adult age, cover in with this coat any body which may be accidentally attached to their surface. There are two specimens of Cypræa rattus in the collection of Mr. Gaskoin, on one of which a Crepidula, and on the other a Barnacle, is evidently so inclosed; and Humphreys, in the Portland catalogue, described two specimens of the same shell in which he had observed a similar occurrence. Such accidents appear, however, to be rare, the extension of the mantle having in itself a strong tendency to prevent other animals from adhering to the surface of these shells.

A similar occurrence may frequently be observed in the shells of the genus Cymbium, the glazed coat of which often includes Balani and particles of sand. The presence of such bodies under the glazed coat in these shells is so constant, that I am inclined to believe that the animal deposits this coat with the view of ridding itself of the irritation caused by the adherent sand and Barnacles rubbing against its foot, as the animal of the Chinese pond muscle (Dipsas plicata) deposits its pearly coat over buttons or spines which are artificially introduced into its shell.

5. *On the Deposition of Shelly Matter by the Foot.*

It has been very generally supposed, that the calcareous matter of which shells are formed is secreted only by the mantle of the animal; and it has consequently been taken for granted, that the expanded base of the Cassides and Personæ, the broad inner lip and the closed back of the Cymbia, and the polished coat on the outer surface of an

Oliva or an Ancillaria, were each and all deposited by some expansion of the mantle.

I have lately, however, had an opportunity of observing the animals of all these, and of many other genera, in the Museum of the Jardin du Roi at Paris, where my excellent friend Professor De Blainville, who was at that time keeper of this part of the collection, kindly allowed me to examine at my leisure all the stores of Mollusca collected together during a long series of years by the late Baron Cuvier, as well as those brought home by MM. Quoy, Gaimard, and Lesson, from the recent voyages of discovery in which those naturalists took part. At the same time I was allowed, by the kindness of M. Quoy, to consult and copy the numerous drawings made by him, during his voyage, from the animals whilst alive and in motion. From this examination I am enabled to state, that in all the shells just named the shelly matter in question is deposited, and most probably secreted, by the upper surface of the foot, which is very large, and not by the mantle, which, on the contrary, is small, and not expanded beyond the edge of the mouth. This is most obviously the case in the Cymbia, Olivæ and Ancillariæ, which have so large a foot that the shell appears to be actually immersed in it. Animals of these genera, drawn from life, are figured by Adanson in his Voyage to Senegal, and by Forskahl in his Fauna Arabica. The Murex anus of Linnæus, which has been referred by Lamarck to his genus Triton, differs in this particular from all the other animals placed by him in that group, and agrees with the genus Cassis, the expanded base round the mouth being produced by the very widely expanded foot: it forms the genus Persona of De Montfort.

It is remarkable that this fact should not have been before observed, more especially as the operculum of all molluscous animals which are furnished with such a protection is secreted by the back of the hinder part of the foot, where there is no extension of the mantle.

6. *On the Operculum.*

The part usually called Operculum is a horny or shelly plate, adherent to the back of the hinder part of the foot of many gasteropod Mollusca. It is always (except, perhaps, in Navicella) attached to the free end of the large muscle by which the animal is affixed to its shell; by the contraction of which the operculum is brought into such a situation as more or less completely to close the mouth of

the shell when the animal is drawn into its cavity. It has hitherto been observed only in those Mollusca which have pectinate branchiæ, and in two genera (Cyclostoma and Helicina) amongst the pneumonobranchous land shells.

The muscle by which the animal is attached to its shell is generally affixed to the hinder part of the cavity, a little within the mouth; in the long spiral shells, which have a small or moderately sized mouth, it is simple, and forms a single scar on the pillar: but in those which have a large mouth and a slightly developed spire, as Neritina and Nerita, it is divided into two portions, one attached at each end of the pillar lip; and in those which have the mouth almost as large as the cavity of the shell, such as Capulus, it is divided into two nearly equal parts, which extend along each side of the cavity, and form what is generally called a horse-shoe-shaped muscular scar. The insertion of the muscle forms similar scars on the inner side of the operculum. Thus in most opercula there is only a single scar: in those of Nerita and Neritina there are two scars, one at each end; and in Capulus the operculum has a horse-shoe-shaped impression. The only exception, as far as I am aware, to this rule, is in the genus Concholepas where the muscle forms a continuous band nearly round the cavity of the shell, while the operculum, which is very small, is marked only with a single subcentral ovate scar.

By far the greater number of these bodies are formed of a more or less condensed cartilaginous matter, similar to the periostracum; and they are often strengthened by a deposit of calcareous shelly matter on their outer side, or more rarely by a similar deposit of greater or less thickness on their inner surface, in some few instances extending to both. The deposit on the inside may be compared to the glassy enamelled coat which is found in the cavities of certain shells, and that on the outer surface may be considered analogous to the hard enamelled coat covering the backs of the Cowries. A few opercula, such as those of the genus Neritina, appear to be truly shelly.

The opercula agree with the valves of shells in being developed on the embryo while included in the egg, and in increasing in size by the addition of new matter round the circumference of the base of the cone of which they are formed: they also agree in the cone being sometimes simple and straight, and sometimes curved into a spiral form. That Adanson regarded them as analogous to the valves is evident from his calling the shells which are provided with these lids on their mouths Sub-bivalves. The principal difference,

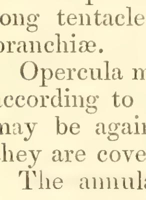
indeed, between the operculum and the valve of a shell consists in the former having no cavity, the cone of which it is formed being either very much depressed, so as to become nearly flat, or even concave, as in the annular or some subannular opercula, or very much compressed, forming only a spiral riband, as in the spiral ones. Opercula are never attached to their shells by ligaments or by any other means than that of the adductor muscle; and they are always free, except in the genus Capulus, which offers a remarkable anomaly in this part being immediately attached by its outer surface to other marine bodies.

It is proper to observe, that in describing the operculum I have called that the anterior margin, which is nearest to the pillar of the shell, as when the animal is walking this part is directed towards its head; and the right and left extremities are the parts corresponding with the right and left sides of the body. When the operculum is placed in this position the left end is that which fits into the front, and the right that which corresponds to the hinder part, of the mouth. This distinction of parts may, at first sight, be thought trifling; but to the practical zoologist its importance is very great. The position of the nucleus of the operculum is, for example, almost the only conchological character by which four distinct genera of shells can be divided into groups, although their animals differ both in external form and in internal anatomy. In the genera Bithynia and Paludina, which have the nucleus of the operculum nearly central, the animal has short tentacles and no air bag, whilst in Ampullaria and Ceratodes, which have the nucleus of the operculum on its anterior side, the animals have very long tentacles, and a large air pouch by the side of the branchiæ.

Opercula may be divided into three very distinct kinds, according to their form and manner of growth, and these may be again subdivided according to the mode in which they are covered with various deposits.

The annular operculum (Fig. 78) may be considered the most simple, the very depressed cone of which it is formed being nearly regular, with the apex more or less central, and the coat of new matter, by which it is increased in size, forming complete rings round its circumference; in which particulars it may be compared to the simple conical shells of the genera Patella, Fissurella, &c. This kind of operculum does not alter its place in the mouth,

Fig. 78.



and the muscle of attachment only moves nearer towards its anterior edge as the addition of new matter on that side renders such a displacement necessary in order to keep the muscle, which enlarges in proportion, in its proper situation with regard to the pillar of the shell.

The subannular opercula (Fig. 79) may be regarded as intermediate between the annular and spiral forms, partially combining the characters of each; but I think it better to consider them apart from the others, inasmuch as they are peculiar to those animals of the Ctenobranchous Mollusca, which are provided with a siphon in front of the mantle for conducting the water to their branchiæ, such as the Murices, Buccina, Strombi, Melaniæ, Melanopsides, Aulodi, and the anomalous genus Phorus. They are all of

Fig. 79.

a horny texture, and are characterised by their very depressed cone being somewhat oblique, with its nucleus placed at or near the left end, and the lines of growth forming more or less complete rings around it, but always becoming wider apart from each other as they approach the right side. The left end, towards which the nucleus is placed, is generally acute, and the opposite extremity rounded, which is just the reverse of what takes place in the annular opercula, where the right end is acute and furnished with a fold proceeding from the nucleus, and the left side is rounded and broad. In most of the opercula of this division the muscular scar occupies the greater part of the internal surface; is marked with more or less regular

concentric rings; and is surrounded by a thickened callous deposit, which is broadest on the outer side (Fig. 79, *b*). This scar appears gradually to approximate towards the right side of the operculum, the part left free, as the scar advances, becoming covered by the callous deposit. The lines on the scar appear to be very constant in the various species, but they are sometimes distorted, and form several centres instead of one. They have no relation to the rings of growth on the outer surface, but have generally a centre of their own, placed at some distance from the left end of the operculum; and they appear to be formed by the successive additions made to the edge of the adductor muscle, which is marked with lines resembling those on the scar. The greater number of these opercula do not alter their relative position in the mouth of the shell; but a few, like those of Fusus fornicatus, in which the end of the cone is slightly curved, move during their lives perhaps to the extent of a quarter or half a turn on the end of the muscle. In some instances, as in the operculum of Strombus, where the foot of the animal is very small, the apex or left extremity is obliquely elevated and free: as the rings of growth are added, this extremity elongates, and acquires such a

Fig. 80.

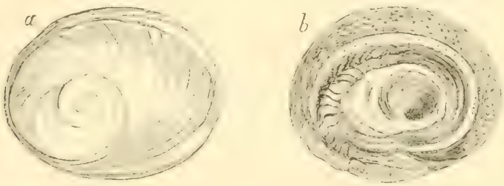
resemblance in form to the claw of an animal, as to have induced the ancients to call such opercula Elks' hoofs (Fig. 80). The scar of attachment is small in comparison with

the size of the operculum, and is situated on its right side: it is cordate and marked with oblique rugose grooves, and with a strong central ridge, which is continued in the form of a rib down the middle of the under side of the free part of the operculum. In some species the posterior edge of the operculum is serrated.

In both the annular and subannular divisions, the disk to which the operculum adheres is formed entirely of the muscle of attachment, and of a membranaceous fringe by which its edge is surrounded. This fringe is free from the back of the foot and is widest posteriorly: it doubtless secretes the coat of the layer of growth, and the deposit which borders the edge of the scar, whilst the muscle itself is provided with the means of secreting the proper coat of the scar.

The spiral opercula are so called because the elongated, cartilaginous or shelly, compressed, riband-shaped cone of which they are formed is twisted into a spire, of few or many whorls (Fig. 81). In these, the new matter by which

Fig. 81.



they increase in size is deposited only on the extremity of the last whorl, which in spiral opercula may be regarded as analogous to the mouth of spiral shells, as the entire circumference of the annular opercula, with their subcentral apex, is analogous to the edge of the base of a Patella. The lines of growth are marked by curved concentric lines extending transversely across the whorls. Opercula of this character vary much in the number of their whorls: when the whorls are few in number the cone increases rapidly in size, and the operculum is of an ovate shape, with the nucleus approximated to the left extremity; when the whorls are more numerous, the cone increases in size more gradually, the nucleus is central, and the operculum is more orbicular. In all these cases the edge of the extremity of the last whorl is constantly anterior, that is to say, when the operculum is in the mouth of the shell, this part of it is directed towards the inner lip; when the operculum is ovate and of few whorls

it generally occupies the whole length of that lip; but in the orbicular and many-whorled opercula, it is directed towards the hinder part of the inner lip, near the angle formed by its junction with the outer. Now every time that the animal adds a new layer on the end of the last whorl, the operculum, to allow of this part continuing to occupy the same position, must make a slight turn backwards on its centre, which is the nucleus of the spire, whether the spire be placed either towards one end or in the centre of the operculum. This rotation on the adductor muscle, although it may at first sight appear improbable, bears a striking analogy to several other phenomena of the same kind which are continually taking place in the animal economy: I need only add two well-known and apposite examples:—1st, the gradual change of situation of the adductor muscle as it passes down the pillar of spiral shells, which in some of the long turreted species, such as Turritella archimedes, where there are as many as thirty whorls, must have been carried to the extent of thirty complete revolutions on this part; and, 2nd, the change of place of the adductor muscle in bivalve shells. In the opercula of the Littorinæ and Naticæ, which consist of a few very rapidly enlarging whorls, the motion and consequent alteration of position of the place of attachment is very gradual and slow; but in those orbicular opercula which are composed of many gradually enlarging whorls, as in the Trochi and Monodontæ, the place of attachment must be continually changing, as many complete revolutions being made as there are whorls in the operculum. These are sometimes extremely numerous: in a small specimen of Turbo pica now before me, there are seventeen or eighteen, and in some Trochi I have counted still more. In the spiral opercula, which thus rotate on their axis, the nucleus, which is the centre of motion, is always included in the scar, and adherent to the muscle of attachment: it is often furnished internally with a small spiral process, buried in the muscle, and resembling the end of a screw. On the contrary, in the annular and subannular opercula, which have no rotatory motion, the nucleus is often removed from the point of attachment, as is well illustrated in those of the Strombi.

In many of those ovate or suborbicular spiral opercula which are formed of a few rapidly enlarging whorls, as, for example, those of the genus Littorina, the inner surface exhibits the lines of growth as well as the outer, there being in these cases no internal deposit. In these opercula the adductor muscle is anterior, and occupies more than half the

disk to which they are attached, the remainder being formed by a membranaceous flap attached to the hinder edge of the muscle. Along the whole anterior edge of the muscle is a ridge, separated from it by a deep groove, which evidently secretes the additions to the operculum; in one specimen I thought that I could observe the edge of this part attached to the ridge, in like manner as the edge of the periostracum is adherent to the mantle of many bivalve shells.

The operculum of the Naticæ is formed on the plan just described; but its inner surface is covered in addition with a smooth pellucid coat, resembling the inner coat of the subannular opercula, and forming a curved tubercle over the nucleus. This coat is marked with two muscular scars, the one lanceolate and central, and the other anterior, linear, and only separated from the first by a narrow polished band; the latter is extended to the back of the tubercle, where it forms a deep oval impression. The adductor muscle occupies the anterior half of the disk, its middle part, which produces the central scar, being of a dark colour, while its front edge, giving rise to the anterior, is white: it is furnished with a thin membranaceous band posteriorly, which is broadest on the right side; and the remainder of the disk is formed of a thick semioval elevated fleshy flap, quite distinct from the back of the foot.

The opercula of some shells which have plaits on their pillar, are very thin, and are furnished with a moveable flap on the left side of their anterior margin, which passes over the plaits. I first observed this in the common Tornatella, and afterwards in Turbo pallidus of Montagu (the genus Odostomia of Dr. Fleming), and have since verified it in Pyramidella. The subannular operculum of Turbinella cornigera has a notch on the middle of its anterior margin, and a plait running from the nucleus; but in this case the flap is not moveable.

The opercula of the genus Neritina agree with those just described, in their ovate form, and in being composed of few and rapidly enlarging whorls; but they appear to be entirely formed of shelly matter, and are marked both externally and internally with very minute concentric lines of growth. Like the operculum of Littorina, they are not covered with any internal or external deposit; but they have several peculiarities. The outer edge of their whorls is furnished with a broad flexible margin; and on the inner side, below the spire, are two diverging processes, the longer of which is curved and forms a tooth, placed near the left end of the anterior edge, which some have supposed to act as a kind

of hinge on the sharp inner lip of the shell. The adductor muscle of this genus is divided into two portions, one placed at each end of the pillar: of these the hinder is the largest, and forms a submarginal scar along the end of the last whorl of the operculum, while the anterior is smaller, and forms an ovate scar behind the two processes. The disk to which these opercula are fixed is like that of Littorina, and there is a slight ridge extending the whole length of the front edge of the muscle, a little anterior to it, which probably secretes the shelly matter of the operculum: in this office it may, perhaps, be assisted by the edge of the hinder part of the mantle, situated just before it.

I might have been inclined to regard the operculum of Navicella as anomalous, had I not had an opportunity of comparing it with its ally Neritina, which has enabled me to explain its structure. In this genus, as in Concholepas and Cryptostoma, the mouth occupies so large a share of the cavity of the shell, and the hinder part of the foot of the animal is so short, that the operculum cannot be folded over in such a manner as to close the aperture. But instead of being very small, as in the two latter genera, the operculum is rather large in comparison with the size of the animal, and appears to serve a new purpose, viz., to separate the viscera from the upper surface of the foot, as the shelly plate does in the genus Crepidula. The part which projects externally is very small, and can only be compared to the flexible cartilaginous fringe on the edge of the outer whorls of the operculum of Neritina; whilst the shelly part which is included in the body of the animal is four times the size of the external portion, and appears to represent the anterior margin and the two processes of the operculum of that genus, greatly developed. The anterior process, which appears to be analogous to the curved projection in Neritina, is produced into a straight lanceolate ridge, and the posterior into a rounded strongly serrated edge; the straightness of these processes evincing that this operculum does not revolve on its axis.

Other ovate spiral opercula of few volutions have a concentrically ridged inner surface (Fig. 80, *b.*), and the outer surface covered with a shelly coat, which varies in thickness in the different genera, being thin in Nacca, Phasianella and some Cyclostomata, and very thick and convex in the genera Turbo and Imperator. The disk to which these opercula are attached is like that of Littorina; but anterior to the muscle there is a very deep groove, into which the operculum can be pushed, and which probably covers the front part

of it like a hood, when the animal is living. I have little doubt that this hood secretes the thick external shelly coat, which is quite out of the reach of the disk, and which increases in size, like the rest of the operculum, by the addition of shelly matter to the edge of its last whorls. That this is really the mode of growth of that part is proved by its being in many cases marked with spiral grooves; while in others the front part of the last whorl is of a different colour from the rest of the operculum, as though it had been covered from the light. It has been sometimes thought that such shelly opercula are attached to the animals by their convex sides; but this is not the case in any of the many specimens that I have examined, in which the opercula were naturally attached to the back of the animal. Some of them have the outer edge of their whorls dilated and free, and occasionally even elevated in such a manner as to form a spiral ridge on the outer side: a structure which may be seen fully developed in the very beautiful operculum of a West Indian Cyclostoma (Cyclostoma mirabile, of Wood's Supplement, t. 7. f. 22).

The operculum of Nerita agrees in form with that of Neritina; but differs in having no cartilage on its edge, which is furnished, instead, with a groove; in its outer surface being covered with a thick variously formed shelly deposit, as in the genus Turbo; and in its inner surface being lined with a thick, callous, polished coat. Between the outer and inner coats there exists a very distinct concentrically striated horny layer, like the operculum of Littorina; and the left muscular scar is deeply grooved, like that of the subannular opercula. This difference in the structure of their opercula forms an excellent distinctive character between these two genera; as do also the differences in the outer surface of those belonging to the genus Nerita between various species of that genus. Thus, for instance, the operculum of N. polita is smooth, with a transversely grooved marginal band; those of N. exuvia, N. ornata and N. chlorostoma are granular; and that of N. peloronta is smooth, with a broad convex marginal rib.

In the orbicular many-whorled opercula of the Trochi, the outside, which is generally concave, exhibits the volutions; and the inside is covered with a thick polished coat, marked with curved lines, produced by the successive enlargements of the muscular scar, radiating from the centre to the circumference.

An examination of the animal and operculum of Trochus pica (which from its large size offers a good illustrative

example of this form), having enabled me to understand in what manner those opercula which appear to be the most complicated in their structure increase in size and thickness, I shall proceed to describe its mode of growth. A comparison with those of the other Trochi leaves little doubt that they are all formed and increase in size on the same principle.

The disk on the back of the foot of the animal to which the operculum is attached, shows three very distinct parts. viz. 1st, the muscle by which the operculum is affixed, which is semilunar, and occupies nearly the whole of the anterior half of the disk, having its hinder edge thin and membranaceous; 2nd, an elongated triangular fleshy band, on the right side of its anterior part, which is separated from the muscle by a deep groove; and 3rd, the back part of the foot, which is raised to the level of the muscle by an elevated border, attached in front to the membranes placed along the sides of the body of the animal, and is marked with minute concentric wrinkles, originating round a longitudinal fissure on its hinder edge, and becoming more and more transverse as they approach nearer to the muscle. This part of the disk merely forms a bed for the operculum to lie upon, without any attachment; it is semicircular, and is prolonged into a narrow process extending up the right side of the triangular fleshy band. If the inner side of the operculum be examined, it will also be found to exhibit three parts, differing from each other in colour and surface, but agreeing exactly in form with the three parts described as found in the disk: 1st, the scar of the muscle, which is green, and occupies nearly the anterior half of the operculum: 2nd, on the left of the scar (that is, when the operculum is turned with its inner side towards the observer), a triangular pale brown spot, occupying the margin of the extremity and a triangular portion of the last volution; and 3rd, a black and polished posterior portion.

There can be no doubt, as these divisions of the operculum agree in shape with the three parts observed in the disk, that they are severally deposited by them; and on further examination it appears that the volutions are in fact formed of three coats, each deposited by one of these parts. The new layers are first added to the extremity of the whorls by the small triangular fleshy band placed on the right side of the muscle. Afterwards, as the operculum is moved round in order to present a new end to the influence of the fleshy band, the newly formed part is covered by a black coat, secreted by the process of the back of the foot which extends up the right side of the band. Both these layers are

eventually covered by a green coat, which is deposited by the surface of the muscle, and the part of this latter coat which is left exposed as the operculum turns round on its axis, is again covered by a second thin black shining coat, deposited by the posterior part of the disk, or that which is formed of the elevated portion of the back of the foot.

That the spiral opercula actually revolve on their axes is proved by the manner in which these coats are deposited, as well as by the circumstance that the front edge of the last volution is always directed towards the hinder part of the inner lip of the mouth of the shell,—a position which it could not constantly retain, in conformity with the manner in which these opercula enlarge, without undergoing this revolving motion. A convincing proof that the green coat of the muscular scar which occupies the outer edge of the front part of the penultimate, and the hinder part of the last whorl has covered all parts of the operculum, except the front half of the last whorl, which in turning has not yet been brought under its influence, may be readily obtained by scratching off the thin black coat, when the green will be found beneath it in all parts except that last referred to. The surface of the scar itself also demonstrates the fact of the revolution, its hinder edge being raised and definite; while its front edge, which is progressive, is double, the posterior of the two portions being elevated, and the anterior, to which the muscle is just becoming attached, being thin and ill defined.

It has been often supposed that shells which have a toothed mouth never have any distinct operculum; but the exceptions as regards annular or spiral opercula are numerous; thus Helicina aureola and H. depressa, and all the Polyodonta, as P. clangulus, &c., have large and regular opercula.

The genus Vermetus has an orbicular horny concave operculum like that of a Trochus, but differing in having a large, orbicular, irregularly grooved, muscular scar, placed in the centre instead of on the anterior side. The outer surface in some of the smaller species, as in V. dentifer,* and V. Adansoni, is furnished with very close spiral elevated laminæ; but in the large species, as V. maximus,† it is homogeneous and horny, and does not exhibit any of the volutions. I have no means of ascertaining whether these opercula revolve, but I am inclined to believe that the spiral ones most probably do.

To these, which every zoologist has been in the habit of

* Sowerby, Genera of Shells. Serpula, fig. 6.

† Gray, Spic. Zool. tab. 5, fig. 3, *a*.

regarding as opercula, but the structure of which has not previously been examined in detail, I am inclined to add two other bodies belonging to ctenobranchous molluscous animals, which have hitherto been generally regarded as anomalous. The first of these is the support, as it was called by its discoverer M. de France, or under valve, as it has since been regarded by some English conchologists, of the genera Capulus and Hipponyx. I am induced to regard this body as analogous to the opercula of other spiral shells, because, on an attentive examination of the animals, I find that it is attached in the same situation and not on the under side of the foot, as most conchologists have supposed; the foot being folded on itself, and the walking disk of other Gasteropods being in these animals (which never move from the place of their first attachment, and consequently require no such expansion), represented by a few crumpled folds placed between the part to which the shelly plate is attached and the head. In this idea I am further confirmed by a somewhat similar structure of the foot in the genus Vermetus, where the back of that organ represents a truncated cylinder, filling up and closing the mouth of the tubular shell. This foot is crowned by a horny operculum, and the walking disk is reduced to a narrow flat band, passing along the front of the cylinder, which band is in some species terminated by two conical processes, situated between that part and the base of the head: the processes have been described as tentacula, which they resemble in form. The shelly plate or operculum of Capulus is formed of concentric shelly laminæ, with a nearly central nucleus, and differs from all other opercula at present known, in being immediately attached, by its outer surface, to other marine bodies, like the lower valves of the Oyster and of Crania, and thus forming the medium by which the animal is retained in its place. The mouth of the shell being nearly as large as the cavity, the adductor muscle, as in other shells of this form, is divided into two broad bands, forming a horse-shoe-shaped, posterior, submarginal, muscular scar, and the operculum is marked with a similar impression.

The second body to which I refer is the vesicular appendage, placed on the back of the hinder part of the foot of the animals belonging to the genus Ianthina,* which appears to

* Cuvier at the time of publishing his Anatomy of Mollusca, appears to have entertained the same theory, for he there properly describes this body as attached to the hinder part of the foot, a little below the usual place of the operculum; but in his Animal Kingdom he seems to have abandoned it, and describes the animal as having no operculum, but having a vesicular organ under its foot.—*Règne Animal*, ed. 2, tom. iii. p. 84.

assist in floating the animal on the surface of the sea, and probably also in supporting the eggs after the death of the parent. This float, as it has been called, I am inclined, from its being situated in the same position as other opercula, to regard as analogous to those bodies in the neighbouring genera.

In the "Medical Repository" for 1821, I first called the attention of conchologists to the importance of the characters furnished by the operculum for the distinction of genera and families; and this subject, although almost neglected in this country, has since been pursued with great assiduity by M. de Blainville and other French conchologists. I have fortunately had an opportunity of examining, either in the cabinet of the British Museum or in the Continental collections which I have visited, the animals of the greater number of genera of shells, and have been thereby enabled to determine that the form and structure of their opercula offer some of the most constant characters for the distinction and arrangement of families and genera; while, on the other hand, I have convinced myself that systematists have been in the habit of placing too much reliance on the mere fact of their presence or absence as a family character, inasmuch as that circumstance alone will scarcely prove of generic importance. Thus in the genus Voluta, the animals of the eight or nine species which I have examined are all destitute of opercula, except Voluta musica, which has an operculum of moderate size. The Olives and Mitres are in the same predicament, most of the large species being destitute of opercula, while the smaller species of both genera are furnished with rather large ones, as may be easily seen in specimens of Oliva eburnea, O. zonalis, or Mitra striatula, in which the animals have been dried; and shells in this state are not uncommon in collections. The species of Cones offer in this respect the same variations. These observations will explain the apparent contradictions of describers, and the frequent controversies that have taken place as to whether these and some other genera have or have not opercula. That their presence or absence is not a family character may be inferred from all the genera of Buccinidæ being provided with them except Harpa and Dolium. And this leads me to remark, that many genera and species which have very large mouths, in comparison with others of the family to which they belong, are destitute of, or have very small, opercula, whilst the others have moderately sized or even large ones. Thus the wide-mouthed Cones, as, for example, Conus geographicus, have no operculum, whilst the other species

have a distinct one: and the genera Cryptostoma and Concholepas have very small opercula, in comparison with the size of their mouths, whilst the other genera allied to them have their opercula nearly as large as the mouths of their shells. The genus Vermetus is in this respect very remarkable: most of the species have the operculum as large as the mouth of the shell; but there is one in the British Museum which has an operculum very small in comparison to the size of the body of the animal, and not one fourth part of the diameter of the tube of shell. Some species of this genus, indeed, are described as having no operculum; and the observation of the above fact induces me to give credit to the description, which I was at first inclined to doubt.

But of all the variations in this particular, those of Capulus and Hipponyx are the most remarkable: some species appear always to have an operculum, which, like the under valve of Crania, differs in thickness according to the form and degree of exposure of the substance to which it is attached:—others, as the common Capulus hungaricus, are generally without operculum, although, according to the observations of Dr. Turton, the last-named species sometimes forms a thin support;—and there are others which, instead of forming an operculum, make for themselves (as has been already alluded to in this paper), a cavity in the substance of the shell to which they are affixed, which is marked with a lunate ridge, corresponding with the muscular scar of the operculum, and doubtless occasioned by the attachment of the adductor muscles to that part of the shell, which is thus protected from the dissolving power of the mantle.

LETTER XXIV.

THE CONCHOLOGIST'S NOMENCLATURE.—THE ACEPHALOUS MOLLUSCA.

WITHOUT a collection of shells you will never become a good conchologist. The collection need not be extensive nor rich in rarities, but it should include specimens illustrative of the families and principal genera; and, that it may fulfil its object, these specimens must be named by your own study. The aid of figures ought at first to be rarely and reluctantly required. The adage that the eye is a readier teacher than the ear, is only partially applicable to objects of science, for no figure can represent the object in all its aspects. If by the aid of the artist we gain a certain amount of knowledge readily, we as certainly lose the benefit resulting from the habit of correct analysis, which the comparison of the object in hand with the description is so well calculated to teach. I have noticed that the student who ever resorts to figures, and depends upon them for the identification of his specimens, commits not only many errors, but soon becomes incapable of enduring the patient criticism which is necessary to ascertain the station and name of nearly allied or abnormal species; and his study, giving no aid to mental culture, loses much of its attraction. Hence, such a student either soon forsakes the pursuit,—it is too facile for continuous interest,—or he lands in mere amateurship. To make your choice pleasant and enduring, you must go deeper and master principles and details, and give an importance to the least of them. You must examine for yourself, and learn the luxury of solving difficulties. Do not, therefore, be seduced by the prevalent use of "Illustrations" to become an iconologist; but let your *vade-mecums* be the descriptive works of such authors as Linnæus, Otho Fabricius, Müller, and Montagu.

To understand the descriptions of these masters of our science, you must, of necessity, learn the peculiar language in which they are written,—the meaning of the words they have invented or applied, to designate the exterior organs of the animals in question, and their varied configuration and sculpture. In conversation, you may hear people complain

of our nomenclature, as a medley of barbarous and jaw-breaking words; but were these as harsh and unspeakable as were the surnames of the Scotch to the musical ear of Milton, yet the fact would not do away with the necessity of your learning them. The artisan would smile at the simplicity of the man who should require him to explain the parts of the intricate machinery he guides, without the use of the terms of his craft.* It is needless, however, to dwell upon such an obvious point; and so, with the humility of an apt scholar, you will now follow me through some dry details, into which it may be impossible, perhaps, to enter without the determination to turn them into future profit.

I. TERMINOLOGY OF THE TUNICATA.

The terms used in describing the constituents of this class are few. The Tunicata are—*simple* (Fig. 82), when every individual is complete in itself; *social*, when several individuals are connected together by a creeping tube; and *compound*, when many are organically combined and associated together to form a common mass.

Fig. 82.

The external covering of the single individual, and of the compound mass, is called its *mantle* or *tunic;* and the inner coat which immediately invests the viscera is the *branchial sac*. There are two corresponding apertures in the mantle and sac; one, distinguished in general by being more elevated than the other, is the *branchial* (Fig. 82, *a*), and the other (*b*) is the *anal* orifice or *vent*. The

* "It is frequent, even with some who pretend to be naturalists, to vilify the fundamental parts of natural history; who view the particular species and bodies in nature; their systematic arrangement; their correct denomination; and the description of their parts and properties; as a study too minute, frivolous, and beneath their notice; whose large views are only directed to what they call the volume of nature, and the great lines in natural history. But I know of no great lines in natural history that are not composed of small ones; nor have I ever had occasion to admire any man's knowledge concerning a great line, that was ignorant of its component parts.

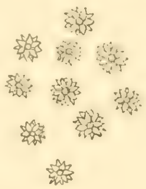
"As for their volume of nature—like other volumes, it consists of pages; and those pages, of lines, words, and letters. But without an acquaintance with these, we have no more right to pretend to understand this boasted volume, than we would to have to understand a book, whose letters, words, lines, and pages, we have never perused."—DR. WALKER, *Essays on Nat. History*, p. 334.

delicate fringes which encircle these orifices are often named the cilia or ciliary processes, but more properly the *tentacular filaments.*

Cellulose — a constituent principle of every vegetable — is also found to constitute a material proportion of the mantle of the simple and social Tunicata ; it forms the soft mass in the cavities of which the groups of individuals of the compound Tunicata are lodged ; and it forms the envelope within which are contained the muscles, the viscera, and the nerves of the Salpæ. This vegetable principle is not to be found in any other class or order of animals. The only apparent exception is afforded by the Doliolum mediterraneum of Otto ; but the fact of the existence of cellulose in it may rather prove the animal to be more nearly related to the Salpæ than to the Beroïdes, with which it has been arranged.*

The Tunicata are all naked or shelless. Mr. Garner has, however, found "calcareous pieces" in some of the simple species. "They consist of two small conical tubes, curiously reticulate in their structure, situated one in each orifice of the cartilaginous tunic, and projecting from it externally. The water, &c., must pass through them."† — In some of the compound Tunicata the common mass is more or less loaded with aggregated crystallisations (Fig. 83) of carbonate of lime, — perhaps the first index of the shell.

Fig. 83.



II. TERMINOLOGY OF THE BIVALVES=CONCHÆ.‡

A *bivalve* shell is one composed of two oppositely corresponding pieces or valves joined together by a hinge occupying a limited portion of their periphery, and on which they open and shut.

The shell of the Pholas has been placed amongst *multivalves,* because it has a few additional pieces placed over and above the hinge, but it is truly bivalve, these accessory pieces having no character of proper valves. The only shells which can perplex you are those which Lamarck has placed in a family denominated Tubicolæ, from the circum-

* "De la Composition et de la Structure des Enveloppes des Tuniciers ; par MM. Löwig et A. Kölliker," in Ann. des Sc. Nat. (1846) v. 193.

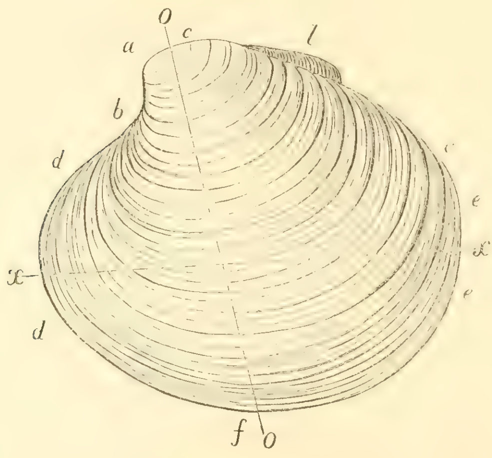
† Charlesworth's Mag. Nat. Hist. ii. 579.

‡ In what relates to the remainder of this letter, I have borrowed so much from Deshayes' Traité Elémentaire, Introd. p. 303—367, that I must pay the debt by this general acknowledgment.

stance of the animals forming a calcareous tube for their protection, and which tube, until the French naturalist explained its true nature, had been considered as the shell itself. To this family belong the Teredo, and the Aspergillum or Water-pot shell, perhaps the most singular of its class. These are truly bivalves, but the proper valves are small, and their existence was long over-looked. In Aspergillum the part generally preserved in collections is the tube, to the inside of which, near its lower extremity, the valves are closely soldered: but in Teredo the true shell is placed without the tube at the posterior extremity. The valves are small, and somewhat anomalous in form, while the tube is long, flexuose, and worm-like, and lines the bore which the creature has made in the wood.

The annexed diagram (Fig. 84) shows the manner in which a Bivalve shell is divided for the purpose of systematic

Fig. 84.



description:—*a*, the apex or beak; *b*, the position of the lunule or areola; *cc*, the superior or dorsal margin or slope, with *l*, the ligament; *dd*, the front margin or slope; *ee*, the posterior or siphonal margin or slope; *f*, the inferior margin or base; *g*, the umbo or umbonal region; *oo*, the longitudinal, and *xx*, the transverse diameters.*

* This is the nomenclature now universally employed, but with Linnæus and Lamarck our anterior slope would be the posterior, and *vice versâ*. Mr. Gray has correctly observed that it is impossible to understand the description of a bivalve shell "without taking into consideration the particular

Bivalve shells are said to be *free*, when the animals have the power of locomotion and can displace themselves; and they are *fixed*, when, attached to a foreign base, they cannot remove from their site. The fixed bivalves are *byssiferous* when attached through the medium of a byssus; *pedunculated*, when moored by a membranous or fleshy pedicle; and *cemented* when adherent by the lower valve being directly glued to the foreign base.

Bivalve shells are *equivalve*, when the valves are alike in size and form; and *inequivalve*, when one valve is less than the other. This inequality is sometimes so great that the lesser valve looks like an operculum to the larger, and it is then described as being *operculiform*. This is only found in shells adherent from cementation, as in some species of Ostrea, in the Hippurites, and the Spherulites. The common oyster and the Spondyli are the best examples of inequivalve shells. A few only of free shells are inequivalve, viz., some Anatinæ, the genus Corbula, and a few Tellinæ; and in these cases the lesser valve is not only less concave but smaller in its circumference than the other.

A *regular* shell is that which is the same in figure in all the individuals of its species. An *irregular* shell is one that is modified and altered more or less in its outline by external influences, so that the individuals of the same species are often unlike in contour and sculpture. The Veneridæ, Tellinæ, &c. are regular shells and equivalve; the Ostreæ are irregular and inequivalve; and the Placunæ are irregular but equivalve.

The length of the bivalve is measured in the direction of a line drawn from the apices to the base or lower margin. (Fig. 84, *o o*). The shell is then said to be *longitudinal* when it is longer than its transverse diameter, *e.g.*, Mytilus, Pinna; and it is *transverse* when the latter diameter exceeds the length, as is instanced in many shells, *e.g.* in Tellinæ, and is carried to excess in the Solenes. The *depth* of the shell is measured by a straight line drawn from the centre of one valve to the centre of the other.

When a bivalve is placed on its base, with the ligament or posterior slope towards the observer, the *right* and *left* valve will correspond with its own sides.

When the beaks look to each other and correspond, and

views of the author whose works we are engaged in consulting."—*Zool. Journ.* i. 207.—Instruments have been invented for measuring shells. Mr. Gray uses a pair of callipers, and D'Orbigny an instrument which he calls a helicometer.—*Ray Reports on Zoology*, 1845, p. 116. They may be dispensed with.

the anterior slope is equal to the posterior and of a like form, the shell is *symmetrical.* To be strictly so, a bivalve should in reality, have four similar areas; but this perfect symmetry is not to be found excepting in some genera of Brachiopods. There is, however, sufficient equality in the areas of Pectunculus, &c., to allow them to be described as symmetrical.

When a line drawn from the umbonal region to the base divides the valve into two equal, or nearly equal, halves, the shell is *equilateral;* and when one side is decidedly longer than the other, the shell is *inequilateral.*

If, when closed, the margins of the valves meet in contact, the shell is *close;* but if the margins do not meet in any point of the circumference, the shell is *gaping.* The gape is commonly on the posterior slope; and it is not uncommon to find a gape in both slopes or ends, as in Solen.

A shell is *auricled* or *eared* when an appendage or process is extended from one or both sides of the apices and separated from them by a line or suture; *e.g.*, Pecten; and when this lateral process is more extended and appears to be continuous with the beaks, the shell is said to be *lobed* or to have *lateral lobes.* When the beaks are prolonged forward, beyond the outline of the valves, the shell is *rostrated.* The Oyster and other cemented shells frequently become rostrated.

When any part of the outline is abruptly interrupted in the circle that it would, if continued, have described, the shell is *truncate.* You have examples in Donax, in Cardium, and in Mya, &c.

When a shell is elongated and swollen equally on both sides, it becomes *cylindrical,* as in Lithodomus; but if the valves are, on the contrary, flattened and almost plane, the shell is *compressed.* If round in the circumference a compressed shell is also *orbicular;* and if the valves are tumid, the shell is *globular,* or *globose.* The terms *heartshaped, lenticular, navicular, rhomboidal,* and *tongueshaped,* explain themselves. A *linear* shell is an elongated shell with the superior and inferior margins parallel to each other and straight, for if the line bends, the shell is *arched* or *arcuated.* The genus Solen affords examples of both structures.

Each valve of a bivalve shell has two surfaces—an *external* and an *internal* one.

The external surface is covered with the *Periostracum* or *Epidermis* varying much in thickness in different genera, and in some so thin and inseparable as to be detected with difficulty. It is then said to be *obsolete,* or wanting. It may be

rough and hairy, or ciliated, or velvety, or scaly, or smooth, dull, or glistening. The periostracum of the genus Trigona is partially covered with a velvet-like silvery coat as if it had been washed over with whitening. Dr. Fleming discovered that this coating was formed of siliceous spicula similar to those of the siliceous sponges. The true nature of the coating is scarcely determined, but Mr. J. E. Gray thinks that it is formed by the animal as it produces the periostracum, and that, consequently, it is a constituent part of the shell.*

The use of the periostracum appears to be to defend the shell from the attacks of boring worms. Hence, it has been remarked that it is ordinarily hairy only in such species as do not bury in the sand or mud, and which, therefore, are more exposed to their enemies than the arenicolous genera.†

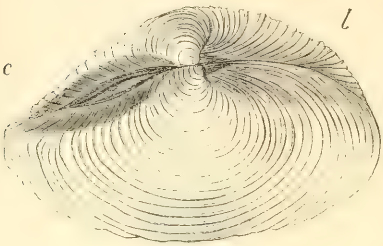
The external surface is variously adorned, and furnished with colours, striæ, grooves, ribs, tubercles, scales, and spinous and foliaceous processes. When these are arranged in the direction of the shell's length, they are said to be *longitudinal;* when in the opposite direction, they are *transverse*, or *concentric;* and when they cross the two directions they are *oblique*. In general, the valves are exactly similar in colouring and sculpture; but there are many exceptions. Of fixed shells, the lower valve differs very often in colour from the upper, the first being white or colourless, while the other may be gaily coloured. The Spondylus and Pecten afford many remarkable instances of this. In sculpture, a difference is rare, but it is exemplified in a common native Tellina, in which the striæ of the two valves are differently disposed. *Obs.* In some Univalves, the sculpture of the young shell differs from that of the old, or mature one. "In the young of Plekocheilus the whole shell is without striæ, and is beautifully corroded on its surface, the plicæ being smooth and distinctly marked, as they are added by the fresh operations of the pallium. In the young of the other snail (Bulimulus undulatus) we observe numerous fine longitudinal and transverse striæ, which it will be vain to look for in the parts added by the animal as it advances in strength; a circumstance that would have led to the multiplication of species, had not specimens been discovered in various stages."‡

The most remarkable parts observable on the external surface, are the *beaks*, the *lunule*, or *areola*, and the *corselet*. (Fig. 85.)

* Ann. and Mag. N. Hist. ser. 2, iv. 296.
† Encyclop. Méthod. Vers. i. 96. Adanson's Senegal, 120.
‡ Rev. L. Guilding in Zool. Journ. iii. 533.

Beaks.—These constitute the apex of the shell: they are prominent points looking to each other, or, more generally, inclined to the anterior slope. They have a tendency to the spiral figure, and terminate the superior, or dorsal margin of the shell. When they are situated decidedly in front, they become *terminal*, as in the mussels; when only approximating to the anterior slope, they are said to be *lateral;* and when near the middle, they are *central.* They are sometimes *obsolete*, or scarcely distinguishable, as in Solen; they are very large, and *heartshaped*, in some cemented shells, as Chama, Diceras, and Gryphus, and they are *spiral* in Isocardia. In almost all genera the beaks have the same inclination; but in some Chamæ they look in opposite directions, and are then *divergent.*

Fig. 85.



The *Lunule* (Fig. 85, *b*) is not to be found in every bivalve. It is seldom observable in the Monomyaires, but very often in the Dimyaries, and is most developed in the Veneridæ. It is a space in the anterior slope, placed immediately underneath the beaks, and usually circumscribed by a line or depression. Its figure is variable,—either *heartshaped* in globular and ventricose shells, or *lanceolated* in flattened shells. The lunule is rarely protuberant, except in its centre, but it usually constitutes a more or less depressed or hollow area, circumscribed, in some cases, by a raised margin. The central line is either close or gaping.

The *Corselet* (Fig. 85, *c*) occupies a portion of the superior and posterior slope of the shell. It is only found in the Dimyaires, and is wanting in many of them, nor is it so distinctly defined as the lunule. It is at its upper part that we find the *labia* and *nymphæ* in such bivalves as have an external ligament. To gain a distinct idea of the corselet, you must examine it in the fossil Trigoniæ, and in the Venus dione of Linnæus,—a common and singular shell, indispensable to your collection. The corselet is in general circumscribed by an angle, a keel, or a series of tubercles, scales, or spines. It is sometimes narrow, and deep, or lanceolate, heartshaped, or oval; and it may be ornamented like the general surface. It is said to be *escutcheoned* when it is di-

vided into two parts, either by a line or by an alteration in the character of its markings, or by a change of its colour.

The *Hinge.*—The hinge consists of the (1) ligament, and (2) of certain projections and fossulæ in the cardinal margin of the shell, those of one valve fitting into the corresponding parts of the other. In a very few instances the teeth are opposite; and in a few other instances the tooth has no opposite and antagonist cavity. This sort of tooth was expressively named a "dens vacuus," by Linnæus; as, for example, in his character of the genus Mya,—"Testæ Cardines dente crasso vacuo." (Fig. 88, *t.*)

The *Ligament* is *internal* when it is entirely concealed from view on the valves being held closed; and it is *external* when we see it projecting outwardly, and occupying the ligamental area.

The ligament is formed of two very distinct substances. One—the *ligament* of Gray—is always external, and is attached to the upper margin of the shell: it is of the same substance as the periostracum, and is somewhat analogous to the ligaments which connect the bones of the vertebrata, for, like them, it is quite inelastic. "In some shells it is very thick and distinct; in others, it is very thin and scarcely visible. In the Pholadæ it appears to be thin, and to have the shelly plates imbedded in its substance." The use of this ligament is to bind the valves together.

The other substance Mr. Gray calls the *cartilage*, being somewhat similar to the cartilage of the vertebrata. It is eminently elastic, and formed of parallel series of condensed transverse fibres, which are directed from the hinge of one valve to the corresponding part of the other. This substance is always situated within the true ligament. When the substances are close together, and similar in form, the cartilage is attached, just below the edge of the ligament, to a protuberance on the dorsal margin of the shell, named the *callus* or *fulcrum*. But when the cartilage is placed at a distance from the ligament, the former is said to be *internal;* and it is enclosed in a cavity amongst the teeth, or in one peculiar to itself, as in Mya. The cartilage is easily distinguishable because of its black colour and pearly lustre; and when dried it is very brilliant, and has a fine display of colours. The only shells that have no cartilage are the Myatropha, where its place is supplied by an abductor muscle. Its use, whether situated in a shelly cavity, or walled in by an inelastic ligament on one side, and pressed upon on the other side by the callus, is to open and keep open the valves.

Imbedded in the ligament, and overlying the hinge, there

are in a very few genera, as Pholas and Xylophaga, two or more calcareous pieces. These are called *accessary valves.*

The *hinge,* or *cardinal margin* of the valves is very variously modified, and offers many important characters to the conchologist to guide him in the classification of the genera. It is formed out of the inner layer of the shell. When it is a mere thickened rim, or a pit-like callus, we say the hinge is *edentulous,* as in Pholas, Pecten, and Ostrea ; but there is usually found on it a number of small projections called *denticles,* or *teeth,* and some excavations called *pits, fossæ,* or *furrows*—the teeth of one valve being, in general, exactly adapted to lock into opposite fossæ, or gutters, in the other valve, or into the spaces between the teeth. When situated immediately under the beaks, the teeth are named the *cardinal,* or *hinge* teeth; and when they are removed from the centre and placed on either the anterior or posterior slopes, they are said to be *lateral.* (Fig. 86 and 87.) The anterior

Figs. 86, 87.

lateral tooth is generally situated at the extremity of the lunule; and the posterior lateral tooth at the extremity of the ligament. The teeth vary in number—one, two, or three,—and sometimes the number is considerable. In the latter case they are described as being *serial,* or the hinge is *multidenticulate,* as in the Arcadæ. The terms used to designate the form and direction of the teeth need no explanation, being used in their ordinary sense.

In some bivalves the hinge is so firmly soldered that it admits of no opening and closing of the valves, or to only a very slight extent; in these, the hinge is *connate,* or *coalite.*

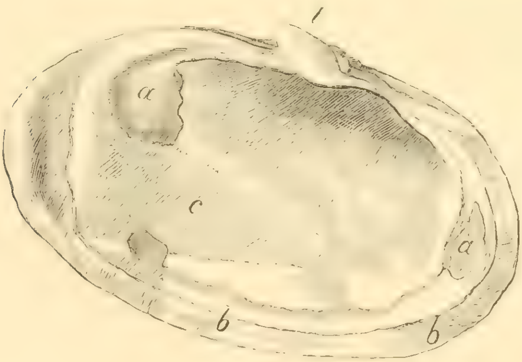
In the family Osteodesmes of Deshayes, the hinge is furnished with a moveable *ossicle* associated with the teeth. It was first observed by Dr. Turton, in Lyonsia striata, who considered it to be a tooth. "This tooth is not a fixed projection from either of the valves, nor formed from the substance of the shell itself, as in all other known shells furnished with teeth; but is an independent process moveable with the ligament, and may be entirely detached from either or both the valves: consequently when the valves are opened, it is found sometimes in the right valve and sometimes in the

left, as the ligament may casually loosen, exhibiting the form of a somewhat elevated transverse tooth. It is of an oblong heart-shaped figure, appearing like a piece of enamel fixed to the point of junction between the valves, with the pointed end directly under the beaks."*—The internal hinge cartilage of the genus Cleidothærus has an elongated testaceous appendage resembling the human clavicle in its form. It is called the *clavicle* by Mr. S. Stutchbury, but it may be reduced to the ossicle.

An edentulous hinge is sometimes a merely thickened *callus* for the insertion of the ligament ; at other times there is a *fossa*, or *pit*, excavated under the beaks. This is named the *scrobiculus*, by Linnæus. It is often marked across with lines or striæ, as in the Oyster.

In the genus Pholas there arises, from the inner part of each valve just under the umbo, a long sickle-shaped process, which may be called the *falciform process*. It has been often called a tooth, and is considered to be a modification of the tooth by Deshayes, but it is not placed similarly to the teeth of other bivalves. Their teeth is represented in Pholas by one or more ribs on the hinge margin, which answer the same purpose as teeth in other shells, keeping the valves in their relative position one with another.

Fig. 88.



If you examine the *internal surface* of a bivalve you may notice that it is impressed more or less distinctly, with a roundish spot on each side (Fig. 88, *a*, *a*), with a narrow border parallel to the lower margin (Fig. 88, *b*, *b*), and with

* Conchylia Insul. Brit. 34. See, also, Encyclop. Meth. Vers. ii. 37. Deshayes, Trait. Elém. de Conchyologie, i. 205.

a sinus running, bay-like, into the middle of the valve from this marginal border (Fig. 88 *e*). The spots marked *a*, *a*, are called the *muscular impressions*, or *scars;* the border, *b*, *b*, is the *pallial margin, or submarginal impression*, and the *sinus*, *e*, is the *pallial sinus*, or *linguiform impression.*

The shells which have two muscular impressions, one towards the anterior and another towards the posterior slope, are called *Dimyaires*, or *bimusculous;* and the shells which have one central or subcentral impression, are called *Monomyaires*, or *unimusculous.** The impressions are made in the shell by the attachments of the *transverse*, or *adductor* muscles or muscle, which pass direct from one valve to the other. You will remember that the office of the hinge-cartilage is to open the valves, and the office of the transverse muscles is to close them and to prevent their being opened too wide asunder —two duties in one office, for which they are purposely constructed, partly of muscular fibre and partly of ligament. The animal, when at rest and submerged, keeps the valves open to a certain extent, to allow a pleasurable expansion of its soft organs; but when alarmed, or deprived of water, it shuts them close with a vigorous effort. The closure is effected by the adductor muscles, which, being voluntary muscles, get weary of their tension and relax their gripe. Then their valves open just far enough to place these muscles in a state of relaxation at their ease, but not so far as to expose too much the soft body they enclose, the gape proper to each species being retained by the ligament adnate to the adductor muscles counteracting the elasticity of the hinge cartilage. The ligament and muscle are not intermingled, but only in juxtaposition. "This ligament is placed on the inner side, close to, or partly attached to, the adductor muscle, as may be observed by cutting the body, usually so called, across, when the two substances will be most distinctly visible, the one muscular and the other eminently fibrous and pearly." That the valves are kept from separating beyond the just limits by the ligament is proved by the circumstance, that when the animal is dead, and the muscle is in a nearly decayed state, the distance is nevertheless retained, nor is made wider when the muscular part is cut through; but instantly on dividing both muscle and ligament, the valves fly back suddenly as far as the mechanism of

* Only a very few of the Monomyaires are, strictly speaking, unimusculous. Besides the large subcentral or posterior impression, there is in most of them a small impression near to and below the hinge. In Avicula there are several of these minute impressions.

the hinge will permit. This admirable structure was first pointed out by Dr. Leach, in 1818.*

The *muscular scars* and *submarginal impression* are present in every bivalve shell, but the *pallial sinus*,† being marked out by the foot, is of course absent in all the genera which are apodous. There is besides to be observed, in many bivalves, an impression on the posterior slope, forming one or two parallel and adjacent shallow furrows; this is called the *siphonal scar*, for it is impressed on the shell by the branchial and anal siphons. Hence the presence of this impression is a proof that the animal had these organs, combined or *adnate* when the furrow is single, and *separate* when the furrow is divided by a raised central line. The length of the siphons is indicated by the length of the furrows.

The inner surface of the bivalves is always smooth, glossy when fresh, frequently nacred or pearly, generally white, but in many tinted with rose-colour, yellow, orange, purple or blue. This colouring is produced, not by glandular secretion like the colours of the external surface, but by the contact of the inner layers with a similarly coloured viscus of the animal, by whose excretion it is stained. Hence the character furnished by this colouring is of little value in distinguishing genera, or even species.

The margin of the valves is variously fashioned, but there is no difficulty in understanding the discriminating terms. It is *thin* and *acute*, or *thickened; even* or *undulated* or *sinuated; smooth* or *serrated.* If the little *denticles* which, by their manifold and equal repetition, constitute the *serrated* character, are made larger and fewer, then a *crenulated* or *crenated* margin is the result; and a *toothed* margin is one with still larger and few projections. The margins of freshwater bivalves are never properly toothed or serrated. The only exception is found in Unio sulcatus of Lea, in which the margin approaches to the dentate character.

In the preceding explanations the Conchifera have been kept exclusively in view, but the Brachiopoda possess likewise a bivalve shell, and it is now necessary to notice a few terms more peculiar to that singular order.

The valves of the shell of the Conchifera, when viewed in their relation to the animal in its natural position, are *right* and *left;* but in the Brachiopods one valve is *superior* and

* Gray in Zool. Journal, i. 217—220.

† Mr. Sowerby, in his Genera of Recent and Fossil Shells, always names this the "impressio muscularis pallii,"—the "muscular impression of the mantle."

the other *inferior*, the superior overlying the dorsal, and the inferior sustaining the ventral aspect of the animal's body.* In a conchiferous Mollusk, on the contrary, the back looks to the superior or cardinal margin, and the belly to the inferior margin or gape.

The shell of the Brachiopods is almost always *regular* and *symmetrical*, viz. a line drawn longitudinally from the summit to the middle of the inferior margin divides it into four equal areas.

Fig. 89.

The *muscular impressions* are more than two and faintly marked. There are usually three or four on each valve. The mantle also adheres throughout very firmly to the inner surface, and leaves no marked impressions (Fig. 89).

When the valves are unequal, as they mostly are in this order, the largest valve is the *dorsal* (Fig. 89). Its apex is more or less elongated, and usually perforated. It is *patelliform* in the Crania and Orbicula, and more or less *pyramidal* in Calceola and some Terebratulæ, in which the inferior or ventral valve is reduced almost to be *operculiform.*

The *beaks* of the valves, when equal, are always opposite and look to each other; when unequal, the beak of the dorsal valve is the largest and most developed.

The beak of the dorsal valve offers to our notice certain modifications which have been used to distinguish groups in the order. It is sometimes short and almost obsolete, but, through a series of species, it is seen gradually to enlarge and to project beyond the valve, sometimes in a pyramidal shape, and sometimes more or less spiral, rounded entirely or, not unfrequently, flattened on the side of the hinge. The most important character, however, is its *perforated* or *entire* state. The perforation is either a *hole* or a deep *sinus* or *notch.* (See Fig. 89). Usually the perforation is on the summit of the beak, which is there observed to be truncated; but it is often found between the summit and the hinge.

* "The perforated valve (Fig. 89) is the *upper* or *dorsal* one, while the other is the *lower* or *ventral* (Fig. 90); this last being usually furnished with an *appendage*, assuming various forms in different species, for the support of the parts of the body of the animal. When the shell is placed on the lower valve with the hole or gap towards the observer, the sides of the shell will correspond with his own."—J. E. Gray, *in Zool. Journ.* i. 209.

When we examine the superior surface of the beak, we may observe that the perforation is completed by two small triangular pieces soldered together on the mesial line, and upon the margins of the beak itself. These pieces are apparent in almost all Terebratulæ,—in a rudimentary state in some species, but becoming large in those which have a greatly prolonged beak. From the shape and connection of these pieces excellent specific characters may be derived. They do not constitute of themselves the entire upper surface of the beak; and there are examples of brachiopod adherent shells, with the beak of the dorsal valve considerably elongated, which show no trace of them. This surface, to which M. de Buch applies the term *area*, has much analogy with the beak-like apex of the oysters and of the Spondyli. In the Terebratulæ we may also notice, on each side of the pieces of the beak, a more or less extended surface which corresponds to the beak of the Crania and the Thecidea; this surface is generally circumscribed externally by an angle, and it is further indicated by its lines or striæ of growth.

In Lingula the valves are equal; in Crania and Orbicula the ventral patelliform valve is larger than the dorsal; but in the majority of Brachiopods the ventral valve is smaller than the dorsal. Not only is it smaller, but its beak is never perforated, and it is often bent to bury itself underneath the cardinal hinge of the dorsal valve. This is the case in the greater number of Terebratula and of Productus, and in all the Thecideæ. Sometimes it is straight, as in Lingula; sometimes recurved as in some Terebratulæ; and in Crania and Orbicula the apex of the ventral valve is more or less elevated and subcentral.

Fig. 90.

But the most admirable part connected with the hinge of the shells of the Brachiopods is the testaceous frame-work called the "appareil apophysaire" by Deshayes, the "internal skeleton" by Owen, and intended to support the fringed arms of the animal, and to keep the valves open, or even to assist in opening them (Fig. 90), for in the Brachiopods there is no cartilage at the hinge for this purpose. There is no trace of this apophysis to be found in the genera Lingula and Orbicula; but rudiments of it appear in some Craniæ; and it goes on through many states until it reaches very con-

siderable complexity in the Terebratula, Productus, and Thecidea. The value of these modifications to the systematist is not great, for he cannot avail himself of them to separate the shells into natural families or even genera. In both Productus and Terebratula, there are species which have the apparatus well developed and spirally twisted, and others in which it is reduced into simple laminæ, more or less projecting. Rudimentary in certain Crania, the apparatus continues to be very simple in the greater number of the Terebratulæ, but it complexes itself in others. Two little ossicles spring and diverge from the hinge margin, and bifurcate towards their points; the lower prong projecting horizontally, meets that of the opposite side, and thus forms a primary arch, as is observable in a certain number of species; the other prong shoots more or less into the centre of the valve, and it is either simple or curved back upon itself to form a branch parallel to and above the first. Approaching the beak, the extremity of this branch or prong bends back horizontally, meets that of the opposite side and coalesces with it, forming in this way a large arch placed above the first.* In the fossil genus Spirifer of Sowerby, the osseous prong, which constitutes the large arch, is twisted into a pyramidal spire or cone. The figure (Fig. 90) will give you a good idea of the "appareil apophysaire," in its fullest development.

On the inner surface of the valves of different genera of Brachiopods, near the middle, there may be observed a notable thickening or elevation. This appears under the form of an obtuse longitudinal rib in the thin valves of the Lingula; but in some Terebratulæ it becomes more developed. There is one in the ventral valve, and two in the dorsal valve, which are separate and divergent. In many species these *crests* are short and obtuse, not reaching beyond the centre of the valves; but in other species they reach the inferior margin, attain considerable prominence, and divide the shell into three equal parts. In the Calceola there is a single median crest with rugæ on each side; and in Thecidea this crest is very prominent, and has on each side a large apophyseal apparatus analogous to that of the Spirifer.

* Sowerby calls the appareil apophysaire, the "shelly processes," which he says, "are sometimes short, simple, and recurved, but sometimes of considerable length, branched and variously bent, and generally anastomising: these generally commence on each side of the hinge, but sometimes near the centre of the shells, and they are sometimes united to the shells at other points."—"*Terebratula*," in *Gen. Rec. and Foss. Shells.*

LETTER XXV.

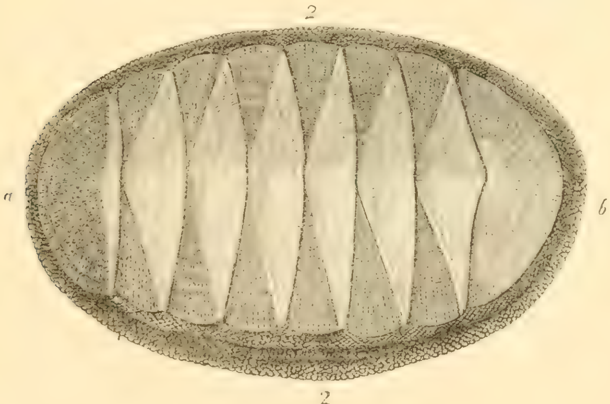
THE CONCHOLOGIST'S NOMENCLATURE. — THE CEPHALOUS MOLLUSCA.

The shells of the Cephalous Mollusca are either, 1, multivalve; 2, simply univalve; 3, spiral or turbinate; or 4, multilocular or chambered.

I. MULTIVALVES = MULTIVALVIA, LIN.

A multivalve shell (Fig. 91) consists of eight pieces (*scuta*) arranged in a series along and across the back of the animal it covers (Fig. 91).* It is peculiar to a single family or section of Gasteropods.

Fig. 91.



The valves are connected together by the mantle forming a *marginal band* or *zone*, which surrounds the whole shell. (Fig. 91, *z*.)

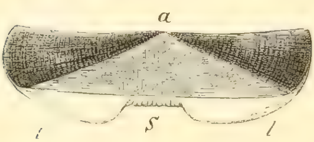
The valves are *imbricate* when they touch each other along the transverse margin; and *separate* when they lie remote

* "Testæ plures, longitudinaliter digestæ, dorso incumbentes."—Linnæus.

from each other. The latter are sometimes buried in the mantle and *hidden*.

The anterior (*a*) and posterior (*b*) valves are semicircular and nearly equal; the intervening are subequal, oblong, and transverse with sloping sides. "The posterior valve, which is placed over the more important organs, is generally the most fully developed, and is the homologue of the shell of the Patella; while the others, which are arranged in front of it, are more imperfect; and the front one is the most rudimentary of the series."—J. E. Gray.

Fig. 92.



The external surface of each valve is divided into a centre and a right and left side. The *apex* (Fig. 92 *a*), more or less marked, occupies the centre, and looks towards the posterior extremity. Each side is divided into two *areas* by a line passing diagonally from the posterior aspect of the apex to the anterior and lateral margin. They are easily distinguishable by being striated or granulated in opposite directions,—the *anterior area* transversely, and the *posterior area* longitudinally. (Fig. 92.)

The inferior margin of the valves, imbedded in the mantle, is marked with neat small *notches*, variable in numbers. Their number may be counted by the porous lines which are to be observed on the inner surface of the valves diverging from the apex to the margin.

The lateral or transverse margin is deeply *sinuated* in the middle, and furnished with a thin prominent rounded process on each side. The *central sinus* (Fig. 92, *s*) is minutely serrulated, and the lateral *lobes* or *wings* (Fig. 92, *l, l*) are also frequently so charactered. These lobes can generally be seen from the under side without separating the valves. There are none on the anterior valve.

In the living animal these lobes are inserted into the substance of the mantle, and hence the valves are subject to its contractions. By this means the snail can roll its shell into the form of a ball more or less perfectly, like the wood-lice.

The *marginal band* varies in breadth and sculpture exceedingly. It is smooth or furfuraceous, shagreened, granular or scaly, hirsute or spinous. The granules and scales are arranged usually in quincunx. The spines are in most collected into tufts.*

* Gray in Ann. and Mag. N. Hist. xx. 69; and in Phil. Trans. 1847, p. 141–5.

II. SIMPLE UNIVALVES = UNIVALVIA ABSQUE SPIRA REGULARI, LIN.

Simple univalves are not twisted spirally round an axis; — they are unwreathed shells, which are *tubular* when they taper to the apex and open at both ends; and *patelliform* when they are conical and hollow like a cup.

Fig. 93.

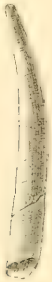
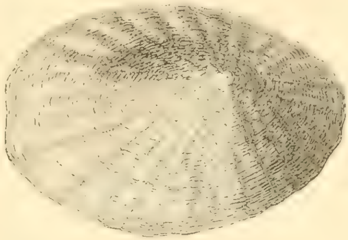


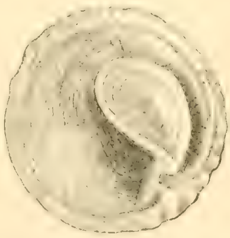
Fig. 94.



The tubular shell (Fig. 93) belongs to a single genus (Dentalium), that of itself constitutes an order in the class.

The conical shell (Fig. 94), although also pertaining principally to a peculiar order of Gasteropods, is not restricted to it. The shell embraces a wide series of similar forms. The simplest is a low cone with the summit obtuse, and the margin entire or angular; a second has the summit perforated; a third has a fissure on the posterior margin; a fourth has the apex pointed and recurved; a fifth has within the hollow a transverse partition; and a sixth has a cup affixed under the dome (Fig. 95). This is a very remarkable structure. Professor Owen assigns a reason for its creation in the following passage. "The necessity for such a superaddition is probably to be sought for in the more active locomotive powers of Calyptræa as compared with Patella; the foot in the former being, from its organization, adapted to more extensive and frequent contractions, would be liable to affect the superimposed viscera if they were in immediate contact with it. A calcareous plate, the first stage of a

Fig. 95.



columella, is, therefore, interposed, which supports the viscera, and separates them from the locomotive organ." *

III. SPIRAL OR TURBINATE UNIVALVES = COCHLEÆ, LIN.

The shells of the Snail and Whelk are examples of spiral univalves. When they cover the body no adjective term is needed to express their position, but when they are imbedded in the mantle, the shell is said to be *internal*, and the Mollusk is said to be *naked*. All internal shells are white or horny, and they are only obsoletely spiral.

Fig. 96.

The annexed figure (Fig. 96) is that of a spiral univalve, in which *a* is the apex or tummit, *s* the spire, *o* the aperture, and *b* the base.

The spire consists of one or more *whorls*, a whorl being a complete revolution of the shell round its axis or columella. The shell figured has seven whorls.

From modifications produced by the plane on which the whorls revolve, the following figures are derived,—

Discoid. When the whorls revolve on a horizontal plane and are applied close to each other, a flat or disc-like shell is the necessary result. In its volutions the shell enlarges insensibly from the centre or point of departure, and hence it follows that every whorl is larger in all its dimensions than the preceding one, and the centre itself is sunken on one or both sides. The sunken or depressed side is said to be *umbilicate*, when the depression is considerable. Ex. Planorbis.

Cylindric. When the whorls are nearly equal in diameter and rise on each other without any marked tapering. Ex. Pupa.

Conical or *pyramidal*. When the base is broad and flat, while the whorls form a spire graduated to a point. Ex. Trochus.

Turbinate. When the whorls rapidly decrease in size and diameter, and form a conical oblique spire longer than the diameter of the body whorl. Ex. Littorina. (Also Fig. 96.)

Globose. When the whorls are few and scarcely raised above the body, so that all the diameters of the shell are nearly equal. Ex. Dolium, Helix.

* Trans. Zool. Soc. Lond. i. 210.

Turreted. When the whorls are many, and form a spire longer than three diameters of the body-whorl. Ex. Turritella.

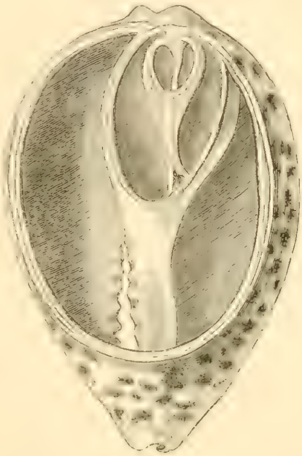
Fusiform. When the shell is thickest in the middle or body-whorl, and tapers towards both the apex and base. Ex. Fusus.

Earshaped. When the spire is minute and the body-whorl very large proportionably, and widely open. Ex. Haliotis.

Involute. When the whorls form a retroverted spire, which is bent in upon the body. Ex. Argonauta.

Convolute. When the whorls are wrapped round the axis so as to embrace each other. Ex. Conus, Bulla. The aperture, of a convolute shell is always parallel to its length.

Fig. 97.



The Cypræa (Fig. 97) is a convolute shell in our definition, but Linnæus describes it as being involute, the margins of the aperture being rolled in when the shell is fully grown and perfected. But the figure of the young and mature Cypræa is very different. The perfect shell, by an addition of calcareous matter to the edges of its lips, as goes on in the formation of every shell, would soon have the aperture entirely closed, as you will perceive on examining any species of that genus. To get rid of this difficulty, Bruguière and others have imagined that the animal threw off the shell when it had become too small for his necessities, and then formed another more capacious, and better fitted for his ease. This theory labours under insurmountable difficulty; nor does it seem required by the circumstances of the case. The Cyprææ, in their immature state, have a very different form from that they have when full grown. When young, they are very thin and brittle, with an evident spire, and a wide aperture, the margins of which are not toothed and inflected, but plain and effuse (Fig. 98). They are then, in fact, convolute shells of the ordinary character, and are obviously enlarged, like all others, by the addition of matter to the

outer lip alone. But maturity brings with it a change in the organs of the animal. The lobes of its cloak become more developed, and ultimately very large; so that, one issuing from each side of the aperture, they can cover the shell, and meet in the centre of the back. These lobes are secretory organs, and pour out an abundance of lime in a vitreous state; and, by their motions spreading it over the outer surface, the shell is thickened, assumes a form totally different from its primary one, and dependent on the new development of the soft parts.

Fig. 98.

To the above forms most univalves may be reduced. Intermediate shapes are expressed by prefixing the diminutive *sub* to the adjective word, as subglobose; or by combining two adjectives together, as ovato-fusiform.

The whorl which contains the aperture is called the *body-whorl*. It is the last formed, and is only finished with the full maturity of the Mollusk. The number of whorls varies of course with the age of the individual, but it seems to be very uniformly the same in the individuals of the same species. Adanson, however, asserts, that in Purpura, Buccinum, and some other genera, the shell of the male has usually more whorls than that of the female, and is at the same time more gracile and elongated. The latter observation you may verify by examining our common whelks, in which it is easy to distinguish the female by the bulged contour of the body-whorl.

On holding a shell with the aperture towards you and the apex aloft, you will perceive that the whorls revolve from right to left. These shells are said to be *dextral* (Fig. 96). When the revolution of the whorls is in the contrary direction, the shell is *sinistral*.* Some dextral shells are occasionally sinistral, and such a specimen is prized from its rarity;† but I do not remember to have seen any sinistral species with a dextral individual.

* "You tell me, that it is generally concluded by philosophers, that the reason of the usuall *turn* of snailes from the left to the right, is the like motion of the sun, and that especially more nord-ward, there having not been hitherto discovered any in our parts of the contrary turn to the sun's motion. But this is not the only case, where they are out, who consult not the stores of nature, but their own phancy."—Lister to Ray. *Phil. Trans.* 1669, p. 1014.

† "My well-informed friend, Mr. Pratt, who obligingly arranged the shells in the Ashmolean Museum, tells me, that he knew a French naturalist who had contrived to obtain a breed of reversed snails, which he sold

When a shell is placed on its base, and the spire points directly upwards, the spire is *erect;* but if it points slanting heavenward, it is *oblique*.

If the spire is abruptly terminated by the loss of its uppermost whorls, it is said to be *decollated.* Few shells exhibit this remarkable character. Bulimus decollatus is the most familiar example. Were it to have the spire unbroken, there would be fourteen or fifteen whorls, but there are only six or seven. When the "Barnet" of Adanson (which is a marine shell) has formed eleven whorls, the upper ones fall off, and only four or five remain; and the "Popel," a species of Cerithium, exhibits the same phenomenon.* The process by which it is effected has been explained in a previous letter. See also Encyclop. Method. v. i. 327. Mr. Stutchbury has seen the Bulimus decollatus forcibly strike the apex of the shell against a stone, for the purpose of decollating itself.†

The whorls usually overlap at the line of junction and are as it were soldered together, but in a few rare examples they are *separate* or detached. The best example of this structure is exhibited in the Wentletrap (Scalaria pretiosa), which has obtained a certain notoriety in the history of Conchology from the large prices which have been given for perfect specimens. "In 1753, at the sale of Commodore Lisle's shells at Longford's, four Wentletraps were sold for 75*l*. 12*s*., viz.: First day, Feb. 21, lot 96, one not quite perfect, 16*l*. 16*s*. Third day, lot 98, a very fine and perfect one, 18*l*. 18*s*. Fourth day, lot 101, one for 16*l*. 16*s*. Sixth day, lot 83, one for 23*l*. 2*s*." ‡

The line which marks and defines the union of the whorls is called the *suture*. It is either plain, or channeled, or raised.

The surface of the whorls may be *plane*, or *convex*, or *angulated*. It is very variously sculptured with striæ, grooves, ridges, murications, spines, ribs, and spinous processes. When these run, or are arranged, in the same direction as the whorls, they are said to be *spirally* drawn or rowed; and

with advantage to the lovers of rarities. When a garden snail is placed with its apex vertical, its aperture expands ordinarily to the left. The line of curvature is swelling towards the right. But varieties occur, though rarely. The rarity gives them value to collectors. The Frenchman obtained a living pair, and produced a fine family, all of whom, from their very birth, went the wrong way; all inclining to the *côté gauche*,—revolutionists from the egg."—DUNCAN'S *Analogies of Organized Beings*, p. 121.

* Senegal, 147, 153. Also Lin. Syst. 1226.

† Carpenter's Gen. and Comp. Physiology, 97.

‡ Da Costa's Elements, 204.

when they cross the whorls, they are said to be *transverse* or *transversely* rowed.

The colours of the external surface, both in kind and pattern, vary infinitely;* and it is this variety and beauty of colouring, joined with equal variety in sculpture and elegance of form, that have drawn towards shells so much admiration in all times.

> "And in the symmetry of their parts is found
> A power, like that of harmony in sound."†

Pliny becomes eloquent in their praise, and I give you his eulogium in the words of Dr. Philemon Holland: —"As for the Pourcelanes or Murices, they have a stronger skaled shell; as also all the kind of Winkles great and small. Wherin a man may see the wonderfull varietie of Nature in this play and pastime of hers, giuing them so many and sundry colours, with such diuersitie of formes and figures; for of them yee shall haue flat and plain, hollow, long, horned like the moon croissant, full round, halfe round, and cut as it were just through the mids, bow-backt, and rising vp, smooth, rough, toothed and indented like a saw, ridged and chamfered between, wrinkling and winding vpward to the top like Caltropes, bearing out sharpe points in the edges, without—foott broad and spread at large, within rolled in pleits. Moreouer, there be other distinct shapes besides all these: some be striped and raied with long streaks, others crested and blasing with a bush of long haire: some againe crisped and

* Blue is rare, and green is not very common. It was once believed that no shell exhibited a blue colour, and it is in reference to this belief, that Linnæus, after his description of Patella pellucida, adds, "Ex hac patet colorem cæruleum etiam dari in Cochleis." *Syst.* 1260.—The colours are often "formally distributed in spots, and squares, and lines;" but often also they are combined and blended gently one with another, or contrasted so as to produce brilliant and exact patterns. Mr. Duncan, after a rapid survey of colour, as exhibited in the Animal Kingdom, adds, "But in no department of nature is such regularity of delineation more strikingly and beautifully diversified, than in the shells of those multivalves, bivalves, and univalves, the Pholades, Tellinæ, Veneres, Nautili, Coni, Volutæ, Trochi, Helices, &c. which enrich the cabinets of the Conchologists."—*Anal. Organ. Beings*, 55.

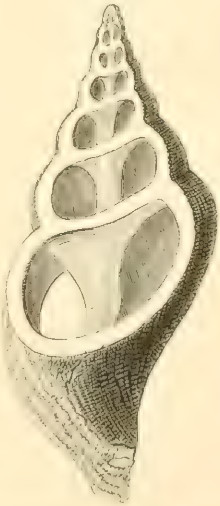
† "Colours are universally agreeable to mankind; and the most incurious and ignorant are attracted by, and delighted with, showy exhibitions of them. Now, all this pleasure is the gratuitous gift of the Creator, and places his benevolence in the strongest possible point of view. There was no reason why man should have distinguished colours at all, much less have been delighted with them; but what is the fact? not only are we gifted with organs exquisitely sensible to the beauty of colours; but, as if solely to gratify this feeling, the whole of Nature, from the highest to the lowest of her productions, forms one gorgeously coloured picture, in which every possible tint is contrasted or associated in every possible manner."—PROUT's *Bridgew. Treatise*, 235.

curled; others made like an hollow gutter or pipe: some fashioned as it were a comb, others waving with plaits one aboue another tile-wise, others framed in the manner of a net or lattise: some are wrought crooked and byas, others spred out directly in length. A man shall see of them those that are made thick and mossie thrust together and compact, others stretcht forth at large: ye shall haue of them wrapt and lapt one within another: and to conclude, yee shall find them run round into a short fast knot, and all their sides vnited together in one: some flat and plain, good to giue a clap, others turning inward crooked like a cornet, made as it were to sound and wind withall." *

The *apex* is to be distinguished almost always by a difference in its colour from the other whorls: it is often horn-coloured, and always unicolorous. It becomes *concealed* more or less completely in some convolute shells when these have attained maturity. This is observable in some Volutes and in the Cowries (Fig. 97).

The imaginary internal axis around which the whorls revolve, is named the *pillar* or *columella* (Fig. 99). When solid and close at the base, the shell is *imperforate;* when open, the base is *umbilicate.* The umbilicus is well exemplified in Trochus and Natica; and still more remarkably in the genus Solarium. It is found only in such shells as have an entire aperture.

Fig. 99.



At maturity, the umbilicus is occasionally obliterated by the normal character of growth of the shell, as in many Helices; or by a deposition of shelly matter. It is then said to be *obtected,* or covered by a *callus.* This is very general in Natica.

The *aperture* occupies a more or less considerable portion of the body-whorl, and is limited to it.

When the margin is entire or, as it were, unbroken or chipped, the aperture is *holostomatous;* but if the margin is interrupted by a sinus, or gutter, or canal, it is *siphonostomatous.* If the margin shows only a wide and shallow depression at its base

* Hist. of the World, i. 253.

or external side, the aperture is said then to be *effuse.* Ex. Ianthina.

The *length* of the aperture is measured in a line continued from the apex of the spire to the base; the *breadth,* in a line drawn across from one side to the other. The *shape* is very various,—round, semilunar, oval, or linear, with many combinations which it is unnecessary to specify.

The side of the aperture next the pillar, is the *inner,* or *columellar* or *left lip;* that on the other side is called the *outer,* or *right lip.* The inner lip is sometimes called the *labrum,* and the outer the *labium.*

When the lips run into each other and form a continuous rim around the aperture, they are said to be *continuous;* but when the superior edge of each terminates on the body-whorl, the lips are *disjunct, separate, interrupted,* or *confluent* with the body. The continuous rim, especially if it be everted, is often called the *peritreme.*

The *inner lip* is often twisted near the base; it may be convex or flattened, smooth or granulous, armed with folds, or plaits, or teeth, straight or oblique,—and all these forms become valuable to the systematist, since they are dependent on corresponding structures in the animal, and lead him to a certain interpretation of their meaning. The columella is also frequently perforated. When very obvious and deeply bored, this perforation has been generally, yet erroneously, described as an umbilicus.

The *outer lip* may be thin and acute, or thickened and obtuse, smooth, or crenulate, or toothed, simple or reflected, plain, or strengthened with an external rib or varix. The rib or varix exists only in shells of zoophagous Mollusca. In land shells, the lip is often thickened and everted on maturity; and in the genus Anostoma, at maturity, the last whorl is turned upwards, so that the aperture appears upon the same plane as the spire. Previous to adultness, "the animal must crawl about, like other snails, with the spire of its shell uppermost; but as soon as it arrives at maturity, and is about to form its complete aperture, it takes a reverse position, and afterwards constantly carries its spire downwards." The reason for this remarkable structure has yet to be ascertained in a better knowledge of the habits of the Anostoma.

In *siphonostomatous* shells, the interruption to the evenness of the rim is always at the base or lower end. Sometimes both ends are effuse or emarginate, as in Cypræa; and in some other zoophagous genera there is a notch at the superior angle of the outer lip. A sinus a little above

the basal one, and on the outer lip, distinguishes some shells.

The interruption may be a mere notch, or a short gutter, or a canal, or rostrum, several inches in length; and there are intermediate formations to connect these extremes. It may be straight, oblique, or retroverted, open, or covered. It is the sheath of the siphonal process, and is a true index to the character of the latter.

Spiral univalves are *operculated* or *non-operculated*. Adanson calls the former *Sub-Bivalves*, a term retained for them by Blainville,* and the propriety of which, in a physiological view, Mr. J. E. Gray has lately attempted to prove.

The following remarks of Oken on this subject are interesting: — "The androgynous or bisexual animal is, as a general rule, asymmetrical.—The mantle also, or the branchial cavity, obeys this want of symmetry. The branchiæ of one side dwindle down; those of the other turn with the mantle towards the head, and the respiratory aperture occurs upon the back.—With the one-sided evolution of the mantle, one shell also is only developed, while the other is stunted or placed under arrest. The snail's shell is one of the Bivalve Mollusc's shells, its operculum is the other. This last is stony, horny, and finally is entirely wanting.—It is remarkable that the right shell has been pretty generally perfected, while the left dwindles down into the operculum; all the snail's openings are therefore on the right side, such as the anus, with the orifices for the escape of the ova and semen."†—I may just observe, that operculated univalves are not the nearest relations to the bivalves in the structure of their living tenants.

The *operculum* is a horny or calcareous plug designed to close the aperture of the shell. It belongs, with very few exceptions, to the shells of pectinibranchial Gasteropods; but indifferently to the zoophagous and phytivorous families amongst them. "It has been observed that shells with toothed columellæ never have opercula: but many instances may be produced to the contrary."—J. E. Gray.

The operculum is affixed above the foot of the animal, on a circumscribed portion of the mantle, distinguished by its denser texture. As its position varies somewhat, we find that when the animal is in motion, the operculum is sometimes placed near the tail, as in the Cones; sometimes near

* Man. de Malacologie, 229. But compare his opinion in this place with his objection to its justness at page 103 of the same work.

† Physiophilosophy, p. 524.

the middle as in the Ricini; and sometimes so near the neck that it plays by a kind of hinge on the margin of the inner lip of the aperture. This is the case in the genus Nerita.

In those Gasteropods which have the operculum seated at a distance from the neck, or remote from the pillar lip, it has its upper point towards the superior angle of the aperture when the animal is retracted; but when the snail protrudes itself the position of the operculum is reversed. This can only be accomplished by a complete rotation of the operculum, and the process may be readily observed in Purpura, in Strombus, in Buccinum, and in many other operculated genera of Gasteropods.

Opercula may be *calcareous* or *horny*. The former exist in comparatively few genera, ex. Nerita, Natica, Turbo, Phasianella; and these are all holosomatous and phytivorous.

In *figure* the opercula vary much, the variation having always a determinate relation to the shape of the aperture, and the number of whorls in the spire. In some genera it is very small proportionably, and cannot close the aperture. This is remarkably exampled in the genus Conus. Some authors designate this rudimentary operculum as *spurious*. "We are apt, however," says the Rev. L. Guilding, "to make use of this word *spurious* without sufficient consideration. We should recollect, when wondering at the smallness or weakness of the horny opercule of some Mollusca, that the species which possess such either live under the sand, reside in safety on the coasts, or quit the waters when they are not feeding, the shell being held down close to the rocks by a dried mucous secretion, as in some Turbinidæ, or by the mere adhesion of the foot, as in Purpura, &c. The operculum, which in many cases would not close the expanded aperture, is only brought into use in cases of great peril, when the hold of the adhesive foot is loosened, the vessels are emptied of mucus, the various secretions, or the poisonous or coloured fluids by which the enemy is to be driven back or baffled, and the animal retires into the narrower whorls, for which alone the operculum is fitted. When the operculum is perfectly solid and testaceous, we may be sure that its possessor commonly resides in places where it is subject to the sudden attacks of dangerous pursuers. Here it will be of ample size, and capable of closing the larger and exterior whorl. The structure and composition of this organ indicate the habits of the inhabitant in so many cases, that its value in generic characters is far greater than many are willing to allow."*

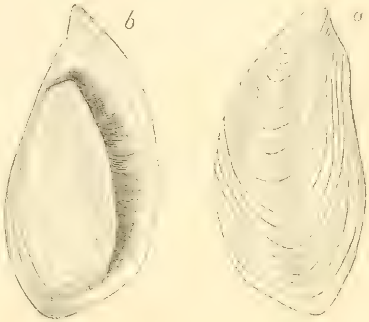
* Zool. Journ. v. 34.

Opercula are *annular* when the whorls of which it consists encircle a central nucleus, and are themselves circular. They are *subannular* when the nucleus is lateral, but with the whorls still forming complete circles: all others are *spiral*.

Fig. 100.

An operculum is *multispiral* when it is formed of numerous narrow volutions with the nucleus near the centre: it is simply *spiral* when the nucleus is lateral, the spires increase rapidly in size, and are few in number (Fig. 100): *unispiral* when there is only one volution, as in Nerita; and *unquiculate* when the apex is terminal, and the whorls half encircle it, always increasing in diameter and size as they follow each other. (Fig. 101. *a* the outer, and *b* the inner surface.)

Fig. 101.



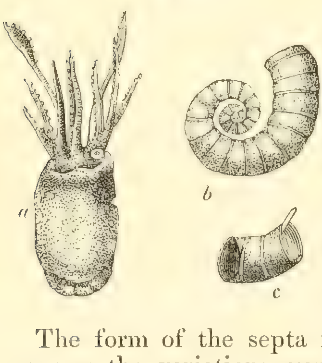
The operculum is confined to pectinibranchial and one or two genera of pulmonated Mollusca. The great bulk of the pulmonated order have no operculum, but, previous to hybernation, many of them form a covering for the aperture of their shells, which has been sometimes described as an operculum. It is now called the *epiphragm*. One genus of the Pulmonifera (Clausilia) possesses a peculiar appendage for closing the aperture, which was first described by Müller. "It consists of a spirally-twisted, thin, shelly-plate, inclosed in the last whorl of the shell, and attached to the columella by an elastic pedicle. When the animal is retracted within its shell, this plate nearly covers the aperture at a little distance within the mouth, and coming in contact with a transverse plait on the outer lip, leaves only a small canal formed between the outer plait and the posterior angle of the mouth, and sometimes an elongated longitudinal plait on the inner lip. When the animal wishes to protrude itself, it pushes the plate on one side into a groove situated between the inner plait and the columella, where it is detained by the pressure of the body of the animal, leaving the aperture free, and when the

animal withdraws itself, the plate springs forward by the elasticity of its pedicle, and closes the aperture. This curious structure, and also the plaits of the mouth, which are intimately connected with it, are not formed until the animal has nearly reached maturity. It is best exhibited by breaking off the outer part of the aperture to the distance of about half a whorl, when it will generally be found free; but in order to exhibit it behind the columella in its natural position, when the animal is exserted, it is necessary to kill the animal in that situation, and then suffer it to dry before the outer lip is broken off, and the pedicle will thus become fastened to the side, by means of the dried mucus; it may, however, at any time be relaxed by a little moisture, when it will instantly resume its elasticity, and spring from its concealment."*

IV. MULTILOCULAR SHELLS.

When the cavity of a shell is divided into cells by transverse septa or partitions, on a preordained plan, the shell is said to be *multilocular*, *polythalamous*, or *chambered*. (Fig. 102, *b*.) There is a multilocular shell amongst our native aquatic Gasteropods; but, with this exception, chambered shells are the produce of the Cephalopods.

Fig. 102.



The shell is *external* or *internal*. In the latter case it is white.

The external shell is spiral, and either *discoid* or *revolute*. When revolute, the whorls are twisted backwards into a spire which is contained within the outer whorl. Ex. Nautilus.

The form of the septa is various, but the terms used to express the variations explain themselves. The chambers communicate by means of a *siphon* (Fig. 102 *c*.) which perforates the septa and runs through the chambers; and according to the position of the spot where the perforation is made, it is named dorsal, central, ventral, or lateral. The recent shells of this description are few in species, nor are the species very numerous in individuals; but the fossil kinds are many and abundant, and some of them have been of a size so

* Gray in Zool. Journ. i. 212

great, that they were not unworthy to play their part with the crocodiles, the Ichthyosauri and Plesiosauri of a former world.

I draw my letters on Terminology to a conclusion with some explanations that apply to shells in general, and which have not been previously adverted to. Linnæus classified the Testacea into the terrestrial, the fluviatile, the lacustrine, the littoral, the maritime, and the pelagic; * and the distinctions are so important that they should be indicated in every good description of a species.

Terrestrial or land-shells, are all univalve and turbinate; and, with rare exceptions, they are non-operculate. So far as I can remember, none of them have the nacred or pearly structure; and none of them have true varices or spinous ribs, or indeed any other external sculpture than spiral striæ or transverse lines of growth. The texture of the shell is light, and its beautiful colours are mostly disposed in well-defined bands; so that a conchologist soon learns to distinguish a land shell from its peculiar texture and colouring, and general aspect. Some Bulimi have a peculiar epidermis. "It is a curious feature in the Philippine species," says Mr. Lovell Reeve, "that the varieties of pattern which constitute their chief ornament reside only in the epidermis. The colours of the shell rarely describe any sort of configuration; they are mostly blended into a uniform tint, over which a fanciful pattern is produced by the epidermis forming a double porous membrane in some places, and a single one only in others, developed, moreover, with the same continuous regularity as the textile marking of a Volute or Cone. This phenomenon is easily detected by immersing the shell in water, when the light portion, or upper porous layer, of the epidermis becomes saturated, and the ground colour of the shell is seen through it; as the moisture evaporates, the epidermis resumes its light appearance. Sir David Brewster, in reply to a letter from Mr. Broderip on this subject, says: 'It appears to me, from very careful observations, that the epidermis consists of two layers, and that it is only the upper layer which is porous, wherever the pattern is white. These white or porous portions of the epidermis differ from the other parts of the upper layer only in having been deprived of, or in never having possessed, the element which gives transparency to the membrane; in the same manner as hydrophanous opal has become white, from the expulsion of its water of crystallization." †

* Syst. Nat. 1070.

† Ann. and Mag. N. Hist. ser. 2. i. 271.

The fluviatile and lacustrine are usually combined under the designation of *fresh-water* shells, for there are no characters in the shell to tell us whether the river or the lake has been its birthplace. Fresh-water shells are bivalve or univalve and spiral, a very few only being simple univalves. They are usually light of texture, and very generally of a greenish or brown horn-colour; and their external surface is plain, unornamented with varied or lively tints, and destitute of varices, ribs, and spinous panoply. Very often the apices of fresh-water shells are corroded as if they had been worm-eaten, when they are said to be *carious*. Some authors have asserted that the corrosions are produced by other Mollusca, or by worms, attempting to destroy the inmate; but it seems due to the operation of some chemical agent, according to Deshayes. The real agent is unknown; and this is a subject that may be recommended to your early examination. In entering upon it, one must bear in mind the interesting researches of Mr. Albany Hancock, demonstrative of the power the siliceous sponges have of making somewhat similar excavations in marine shells.

We approach the maritime shells through a tribe which love the brackish waters, created at the mouths of rivers by the mixture of their water with that of the sea; and these shells have the mixed and uncertain character of their position. Look to the dark-hued Melaniæ and to the Cerithia.—Littoral shells have the decided features which a sea-origin gives to shells, and which it is in general easy to recognise; but not always, for there are some on whose habitat conchologists have not yet ventured to decide. The Cyclostoma flavum is a terrestrial snail whose shell "has all the aspect of a marine" one, bearing "a close resemblance to Littorina, especially in its operculum;" * and the Natica helicoides was pronounced to be a Paludina, until it was discovered to be the inhabitant of sea-banks at a depth of full thirty fathoms.—The principal feature of a sea-shell is the density and whiteness of its structure, and the varied and vivid colouring of its outer surface. These colours are modified a good deal by latitude, light, and by the depth of water in which sea-shells are bred and pass their lives. How varied, vivid, and beautiful are the testaceous Mollusca of tropical seas and of tropical climes! How sober and subdued are those which inhabit our northern shores! The terrestrial Helices, being most exposed to the operation of light, vary most in their colours; while those shells which

* Broderip in Proc. Zool. Soc. ii. 59.

are concealed within the bodies of their snails are always white, as are also those which live in holes whence they never issue. Another striking proof of the blanching effect of darkness is furnished by some bivalve shells permanently affixed by their lower valve, which is constantly white, while the upper one may possibly be variegated with bright colours. The Spondyli, and a number of Pectens, afford examples of this contrast between their valves. Olivi has further remarked, that the shells which are enveloped in sponges, or other foreign bodies, or which burrow in sand, or even which live in constantly shaded places, are much paler than those which crawl about unprotected from the light; and even the exposed parts of the same shell are more highly coloured than the parts which are shaded.

On this point, Professor Edward Forbes has the following remarks:—" A comparison of the Testacea and other animals of the lowest zones with those of the higher, exhibits a very great distinction in the hues of the species, those of the depths being for the most part white or colourless, whilst those of the higher regions, in a great number of instances, exhibit brilliant combinations of colour. The results of an inquiry into this subject are as follows:

" The majority of shells of the lowest zone, are white or transparent: if tinted, rose is the hue: a very few exhibit markings of any other colour. In the seventh region, white species are also very abundant, though by no means forming a proportion so great as in the eighth. Brownish-red, the prevalent hue of the Brachiopoda, also gives a character of colour to the fauna of this zone: the Crustacea found in it are red. In the sixth zone, the colours become brighter, reds and yellows prevailing, generally, however, uniformly colouring the shell. In the fifth region many species are banded or clouded with various combinations of colours, and the number of white species has greatly diminished. In the fourth, purple hues are frequent, and contrasts of colour common. In the third and second, green and blue tints are met with, sometimes very vivid, but the gayest combinations of colour are seen in the littoral zone, as well as the most brilliant whites.

" The animals of Testacea, and the Radiata of the higher zones, are much more brilliantly coloured than those of the lower, where they are usually white, whatever the hue of the shell may be. Thus, the genus Trochus is an example of a group of forms mostly presenting the most brilliant hues, both of shell and animal; but whilst the animals of such species as inhabit the littoral zone, are gaily chequered

with many vivid hues, those of the greater depth, though their shells are almost as brightly coloured as the coverings of their allies nearer the surface, have their animals for the most part of an uniform yellow or reddish hue, or else entirely white.

"The chief cause of this increase of intensity of colour as we ascend, is doubtless the increased amount of light above a certain depth. But the feeding grounds of the animals would appear to exert a modifying influence, and the reds and greens may be in many cases attributed to the abundance of nullipore, and of the Caulerpa prolifera, a sea-weed of the most brilliant pea-green, the fronds of which the Mollusca of that colour, such as Nerita viridis, make their chosen residence."*

And now I bid you a short farewell with the repetition of my former advice, to learn the nomenclature of this little corner of natural history, by an actual examination of examples in your own collection; and you might conduct that examination in such a sure way, that it will lead you to discover the position of the object in the system, and the name it bears amongst those with whom you wish in future to hold occasional converse. Listen to the words of one of the greatest of men in modern times:

"Natural history, in fact, is one of those sciences in which genius is impotent, unless seconded by power; and the efforts of power vain, unless its results are arranged by the co-operation of genius.—The names, which man is ordered to impose, are not incoherent signs applied by chance to some isolated objects. To render them appropriate and significant, the objects, as it is said, must pass before the namer; in other words, he must compare these objects, apprehend the relations of their similarity and difference, and classify them; which he cannot do unless he see them together, and make himself intimately acquainted with them. In short, to name well, taking the word in its fullest acceptation, it is necessary not only to know well, but, it may be said, to know all. The superstition of the Cabalists believed in the magic power of names. This was a false consequence of a principle, that names, were they perfect, would represent the essence and aggregate of things.

"Such is the object of this department of science, which unreflecting minds would doom to contempt, under the name of Nomenclature. To refute their assertions, it is only necessary to repeat the fundamental condition which we

* On Algean Invertebrata, in Reports Brit. Assoc. 1843, p. 172—3.

have just announced, namely, that to name well, it is necessary to know well."*

If this passage may appositely close this letter, it may with equal propriety furnish a motto for my next; and incline you to lend a more willing ear to my exposition of system after system, each of them being the best index you can have to the condition of Conchology at the period of its publication.

* Cuvier in Edinb. New Phil. Journ. April 1829, p. 2.

LETTER XXVI.

THE HISTORY OF CONCHOLOGY FROM ARISTOTLE TO CUVIER.

The foundations of Conchology were laid by Aristotle on those broad and rational views which characterize all his works on the Natural History of Animals, and which are worthy of his own reputation as a philosopher, and of the inquisitive and intelligent society to whom they were delivered. The structure and habits of the creatures embraced in this section of natural science were the main objects of his study, while their relations to the other animated entities by which they are surrounded, and their own mutual affinities were not forgotten, although undoubtedly the classification of them appears to have been considered a matter of secondary importance, and such as it is, was rather forced upon him than invented to give some degree of method and generalization to the expression of the results of his inquiries. To censure this Father for the incompleteness, or even his want of a conchological system, is inconsiderately done, for it must be obvious that no system can be otherwise than defective and artificial until discovery has, in a long and lingering progress, collected together a large magazine of materials, among which there shall at least be found a type of every modification of structure exhibited in the class.* But in his age the number of shells known was very confined, and to have advanced beyond the primary divisions of them into univalves, bivalves, and turbinated kinds, could be of no possible utility, and might have been hurtful to a further progress, for "the over early and peremptory reduction of knowledge into arts and methods" is an error from which, as Bacon has justly remarked, "sciences receive small or no augmentation." †

* "Cependant comme Aristote n'a pas jugé nécessaire de former un cadre zoologique, quelques personnes ont prétendu que son ouvrage manquait de méthode. Assurément ces personnes n'avaient qu'un esprit très superficiel."—Cuvier, *Hist. des Sc. Nat.* i. 147.

† "Another error, of a diverse nature from all the former, is the over-early and peremptory reduction of knowledge into arts and methods; from which time commonly sciences receive small or no augmentation. But as young men, when they knit and shape perfectly, do seldom grow to a further

His views were higher, and his researches were pushed in the only direction in which they could be made available. He has left us a history of the Cephalopods remarkable for its fulness and accuracy, and equally remarkable for its exemption from the marvels and puerilities which disfigure the same history as delivered by his successors; and although there may be less of observation and fact in his account of the shelled Molluscans, yet we find the same ends kept ever in view, and the incessant effort to attain his object by attention to the habits of the animals, and an examination of their anatomy. The numerous defects, obscurities, and errors which a vain criticism might readily detect in his details under both of these heads, are justly attributable to the accident of position, for he was the first to track the road without the guide of a fixed nomenclature, and without the light which analogy could lend, — anatomy at this period being scarcely practised, and physiology almost unknown.* By his own researches he was enabled to characterize several groups of Testacea, with some degree of precision, and to acquaint himself with many valuable particulars of their structure and economy, and although some of his general corollaries from these are hasty, yet even in this minor department of study the Stagyrite claims our admiration for his industry and sagacity, and our gratitude for giving us an example of scientific inquiry which it were well to follow.†

But the spring which welled so pure and copiously had no issue to its waters. Aristotle had no successor in testaceology among his countrymen: and when literature fled the shores of Attica, and found its unwilling way to Rome, it was unattended by the natural sciences. In the constitution

stature; so knowledge, while it is in aphorisms and observations, it is in growth: but when once is comprehended in exact methods, it may perchance be further polished and illustrated, and accommodated for use and practice; but it increaseth no more in bulk and substance."—*Advanc. of Learning*, p. 51. Duod. Pickering, 1840.—Also Sprengel, Hist. de la Médecine, i. 400.

* "Tant d'eminens services rendus à l'anatomie comparée et à la zoologie, doivent lui faire pardonner quelques erreurs, dont les naturalistes du dix-huitième siècle, qui se font une gloire de rebaisser son mérite, ne sont pas même exempts."—SPRENGEL, *Hist. de la Médecine*, i. 398.

† "Parmi les mollusques, Aristote désigne particulièrement la seiche, le calmar, le poulpe, l'argonaute, et fait remarquer, ce que l'on niait encore il y a peu de temps, que ce dernier animal n'est pas attaché à sa coquille comme les autres testacés. Il décrit sommairement tous les organes des mollusques, et mentionne même leur cerveau."—CUVIER, *Hist. des Sc. Nat.* i. 150.—The labours of Aristotle have never been more generously or more highly appreciated than by Cuvier, whose own knowledge entitled him to sit as the judge thereon. See the Hist. des Sc. Nat. i. 130, *et seq.*; and the Edinb. New Phil. Journ. xxiii. 60—75.

of society among the Romans, it is not difficult to find causes for their total neglect of natural history; * and these operated with peculiar force when Pliny began to collect together the materials of his great encyclopædia. Devoted in an especial manner to a public life, the Romans were negligent of a study, which, so far from enhancing their reputation with the people, required a comparative seclusion to be successfully pursued; while the disrelish for every science requiring a continuous and sober observation of facts and experiments was heightened, at the period we refer to, by a general luxury that had risen to an almost incredible pitch, and by the mental excitability produced by their foreign conquests and discoveries; for the tales of their travellers, and the new and uncommon animals sent home from every quarter to supply the theatre and circus, had rendered the minds of the people—one and all—pliant to credulity, and apt to receive every monstrous tale, and equally indisposed to attend to the simple phenomena displayed in the ordinary economy of animal life. Pliny largely participated the taste and credulity of his age, and hence his work is the very antitype of the Greeks,—ample in its details of the use and value of pearls and Tyrian purple, of anecdotes of the follies of the rich in their dress, and in their dishes of snails and oysters, &c.; while he caters from every source wonderful stories of the feats of gigantic cuttles, and of the surprising intelligence and habits of these and other Molluscans which God verily hath made, in harmony with their lower organization, feeble of instinct and in power. To Conchology as a science he has added nothing which Aristotle did not supply; but he furnishes some anecdotes for a chapter on its economical applications, and has graced its history with some tramontane and amusing fictions.

Of the ancients, Aristotle and Pliny are the only names which merit quotation in a history of conchology, and many centuries elapse before we again meet with one whose writings give some indication of its progress. The turmoil of society which accompanied and followed the decline and fall of the Roman Empire,—the engrossing nature of the religion and superstitions of the dark ages,—the exclusive attention bestowed on the writings of the ancients at the revival

* "Cette lenteur de civilisation chez les Romains, qui d'ailleurs envoyaient des ambassadeurs aux Grecs, fut le résultat de leur politique, qui repoussait les arts et les sciences comme des choses capables d'amollir les hommes, et par conséquent de détruire les mœurs guerrières de la république. Pendant plusieurs siècles Rome n'eut aucun écrivain."—Cuvier, *Hist. des Sc. Nat.* i. 213.—Also Craigie in Edinb. New Phil. Journ. xxiv. 156.

of letters,—and the higher claims of higher studies when civility and wealth had begun to diffuse a taste for original compositions, and gave encouragement and leisure to men of science and letters,—were all obliterative of a pursuit which was solely ornamental, and had no attraction except to those chosen few who found in the contemplation of Nature's works their principal gratification. That this number was not inconsiderable is certain, for otherwise it seems impossible to account for the publication of the voluminous and expensively illustrated books on Natural History, which issued from the press within, or shortly after, the first century after the invention of printing.* And indeed the monastic system, and its institutions, must have been favourable to the growth of such feelings, giving the necessary leisure and seclusion, while nature, presenting daily her works and phenomena, and her seasonal changes to these recluses, dull but not dead to their influence, insensibly operated and gave direction to the employment of their minds. It may be that these earliest works were not devoted even in part to conchology, but Natural History as one never advances without advantage to every department, and even this minor branch had soon its due share of love and notice. The vast volumes of Albertus Magnus,† Belon,‡ Rondeletius,§ Gesner,|| and Aldrovandus,¶ contain each of them books devoted to it; and although the original facts they disclose are very few in proportion to the mass heaped up in their folios, yet the criticism they have often received as the receptacles of lumber rather than museums of well-arranged records, seems to be unnecessarily harsh and severe. The study of the ancients, and the elucidation of their difficulties, was still a favourite object with men of literature, and when these early naturalists betook themselves to the writings which had come down to them, rather than to the observations of things themselves, they but followed the bent of their compeers and consulted the taste of their age. Their works are laborious compilations, in which everything, however remotely connected with the subject in hand, good or bad, true or false,

* This great discovery was made about the year 1440, but it was several years later than this before much use was made of it. See Hallam's Literature of Europe, i. 210, &c.

† His writings "have been collected, in twenty-one volumes folio, by the Dominican Peter Jammi, and published at Lyons in 1651. After setting aside much that is spurious, Albert may pass for the most fertile writer in the world."—Hallam, *Introd. Literature of Europe*, i. 159. He was born in 1193, and died in 1280.

‡ 1551. § 1554. || 1558. ¶ 1599.

—whether recorded by grave philosopher, or sung or feigned by poet or traveller,—finds a place without any nicety as to its probability or conformity to the organization of the animals. On the contrary, there is evidently a strong predilection in their worthy authors to retail and believe every tale of instinct or use which might raise the object, however low and loathly, in our estimation,—a greater love of the marvels of Pliny, than of the sobrieties of Aristotle. Still, with all their faults, the reader will find them not void of novelty, either in philosophical remark, or in the record of new creatures; and the plan adopted by them of giving figures of the species, was a most important step towards facilitating the progress of the science.* To look for anything that deserves the name of System in their works, appears next to absurd; they evidently had not yet felt its want, and had no distinct idea of the necessity or utility of any beyond what gave a convenient heading to their chapters. What little they do give us of arrangement, may be said to be more or less literally borrowed from Aristotle.

Fabius Columna, whose works were published even prior to those of Aldrovandus, was a naturalist apparently of superior ability, for he had greater self-reliance, and did look at what nature presented to him, without the use of the refractive medium of ancient authority. The illegitimate cadet of a noble Neapolitan family, he assumed for his motto "his destituta fortior," covertly alluding to the advantages which the accident of his birth lost and gave him. He was born in 1567, and died in 1650. Educated to the practice of medicine, his studies were turned in a peculiar direction, by his search after a specific for epilepsy, a disease with which, from his youth, he had been afflicted. He vainly dreamed that could he discover the plant which ancient authorities vaunted as remedial of his cruel malady, he had made the discovery of its cure; and led on by this delusive hope, he studied the species mentioned by his authorities, with critical care, and in vain.

He carried the same critical spirit into his zoological

* "Without the tool that presents figures to the eye, not the press itself could have diffused an adequate knowledge either of anatomy or of natural history." "The Dyalogus creaturarum moralizatus, of which the first edition was published at Gouda, 1480, seems to be nearly, if not altogether, the earliest of these" books adorned and illustrated with woodcuts. Hallam's Introd. to the Literature of Europe, i. 260. — Aristotle illustrated his writings with designs, but none of these have been preserved. One of them is said to have represented the Sepia in the act of laying its eggs.—Cuv. Hist. Sc. Nat. i. 132: Sprengel, Hist. de la Méd. i. 392.

inquiries. Two of his works therein bear the date of 1616;* and they are illustrated with excellent figures of species hitherto unnoticed, drawn and etched by himself. One of his new species is the Ianthina; and the observation of its property of shedding a purple fluid when alarmed, led him undoubtedly to his learned and interesting research as to the true animal that furnished the Tyrian purple. In the treatise which he published on this subject, his learning and critical acumen are conspicuous, and not less so his reliance on his own observations, which were made his guide in interpreting the obscure and imperfect passages which the ancients had left as our only records of a lost art. He was not the author of a mere vexed commentary, and only a learned and laborious compilator; but in Fabius Columna we find something more promising to futurity,—a naturalist who knew how to avail himself of what had been done, and who could aid the growth of his chosen subject by facts of his own providing.†

The writings of this period afford good evidence of a growing and considerably extended taste for the contemplation of Shells, which was kept alive and diffused by the activity of a daily enlarging commerce furnishing, to collectors and amateurs, numerous novelties of uncommon forms and beauty to gratify, and at the same time to stimulate their curiosity. Hence also the origin of museums, of which Aldrovandus is usually said to have set the example; ‡ and of these Shells made a large and favourite part from their beauty and variety, and from the ease with which they were procured and preserved. These museums soon became rather numerous in Italy and Germany, and although they were undoubtedly formed more for the gratification of the taste of their owners, than with any views towards science, and hence arranged in fantastic and picturesque designs, still it is from their institution that we date the origin of Conchology as a separate branch of natural history. The catalogues published of a few of the most considerable of these museums are among the works generally enumerated as worthy of quotation in the history of Conchology, and it was the

* "De Aquatilibus conchis, aliisque animalibus libellus."—"De Purpureâ, ab animali testaceo fusâ, de hoc ipso animali aliisque varioribus testaceis quibusdam tractatus."

† See Cuvier, Hist. des Sc. Nat. ii. 98, &c.

‡ Haller, however, asserts that Gesner was the first who formed a museum. Smith's Tracts, p. 66. Deshayes ascribes the origin of museums to the apothecary, who exposed to vulgar gaze unusual objects to attract notice and make money.—Trait. Element. i. 49. The reader will be reminded by this of Shakspeare's character of the apothecary, and of his rare collection.

love of making collections of shells separately, that evidently gave origin to the works of Bonanni and Lister, the first which treated exclusively of these natural objects.

Bonanni's work was published in the year 1681, and from its title — " Recreatio Mentis et Oculi in observatione Animalium testaceorum"*—was probably intended to be a book of luxury, exhibiting in its plates whatever amongst shells might please the eye or refocate the unoccupied mind. It is, properly speaking, however, an introduction to Conchology, and in this view of it, the volume becomes interesting, since it affords the means by which the extent of the knowledge of Conchology at that period may be estimated. Of the writings of his immediate predecessors he speaks very slightingly: they remind him, he says, by their boastings when these are compared with their deeds, of those birds which floating aloft in the heavens draw notice by the amplitude of their spread of wing and the fulness of their plumage, but captured and plucked, the exility of their corpse proves to the sportsman how much he had been deceived. The treatise is divided into four parts: in the first, he proves, to his own satisfaction, that the study of shells is not a puerile but a wise and profitable occupation; investigates the mode of generation both of living and fossilized species; declares the fit materials from which they are formed, and takes occasion to talk learnedly of water, earths, nitre and petrifying humours; he descants on their colours, forms, and properties by which the Creator renders them visible to the privileged minds of philosophers; and lastly, enumerates their other uses to man, and what relates to them as precious ornaments for museums, of the more remarkable of which we have a particular account in his 12th chapter. In the second part Bonanni describes each shell separately, noticing their parts, form, colours, names, and the seas which they inhabit. In the third part he propounds about forty problems or hard questions, annexing reasons or " an argument" to the dark and doubtful, by which a ray of truth may be thrown on them, and they may be made visible at least to the mental eye; he shows that pearls cannot be formed from dew, as Pliny would persuade us; — that they are not the young but a disease of conchs; he explains why a shell applied to the ear seems, by its murmurings, to lament

* Recreatio Mentis et Oculi in observatione Animalium testaceorum, curiosis Naturæ inspectoribus Italico sermone primum proposita a P. Philippo Bonanno Societatis Jesu, nunc denuo ab eodem Latine oblata, centum additis testaceorum Iconibus, circa quæ varia problemata proponuntur. Romæ, 1684, 4to.

its native sea; inquires into the causes of shells being more abundant in the sea than on the land, and especially in the Indian Ocean, where they are also more beautifully pictured; why they are principally coloured on the exterior; wherefore they grow hard, seeing they are formed out of soft water; why they are twisted into many spires; why their snails have scarcely any diversity of members; why they are destitute of teeth, a heart, and bones; why nature denies them bile, and a liver, and a spleen; why they grow lean on the wane of the moon; why they are slow and stoltish; why the juice of the Pholas is luminous at night; why among their various colours the cerulean is not to be found; and other such problems hitherto unargued or propounded,—not omitting to inquire learnedly whether the Remora, that stayed the ship sent from Periander on a cruel voyage to the Cape of Gnidos, was actually the shell called in consequence the Venus-shell, and "in regard whereof, the inhabitants of Gnidos doe honour and consecrate the said Porcellane within their temple of Venus." The fourth and last part is occupied with the plates and figures described in the second, distributed into three classes, viz., the univalves not turbinate, the bivalves, and the turbinate univalves.

This slight outline of Bonanni's book is, perhaps, sufficient to enable you to appreciate its value, and the character of the writer. He was a Jesuit, with attainments and natural talents which, though respectable, certainly do not raise him above the level of his age,—perhaps he was under it,—better acquainted with the writings of his predecessors than of his contemporaries,—with the tastes of a virtuoso rather than of the man of science, skilful in all the vain logomachies of the schoolmen, and willing to give a ready assent to every thing which had ancient authority in its favour, but jealous and distrustful of all that was novel, and of every discovery that would carry knowledge forward.* Hence we find his anatomy of shell-fish inferior to that of Aristotle's, and his arrangement of them nearly the same; hence his advocacy of the doctrine of spontaneous generation, when his contemporary Redi had demonstrated its absurdity; hence his exclusive attention to the form and colour of shells to his total oversight of conchology as a branch of general physiology; hence also his fondness in propounding, his copiousness in solving occult questions which, if resolved, were of no utility,

* "Trop attaché aux sentimens d'Aristote et des anciens, il n'a jamais voulu se rendre aux découvertes et aux experiences des modernes, particulièrement sur les Coquillages fossiles qu'il croit être des jeux de la Nature."—D'ARGENVILLE, *Conchyliologie*, p. 114.

but which were really beyond the province of human inquiry; hence the discussion wherefore shellfish were defective in this and that organ, without the slightest effort to ascertain whether that deficiency was a fact; and hence, in short, the reason that his volume contains not a single fact additional to the stock of knowledge in his own province, for we do not find that he has "treated of the formation of shells in a manner more philosophical than could have been expected at such a period," as Maton and Racket have asserted.* But we have no wish to depreciate Bonanni, who, as we have already mentioned, was a man of learning and repute, and it is not discreditable to an author that he is affirmed not to have anticipated his age: we have drawn his character as we think fairly, and it is a fair representation, too, of the bulk of conchologists of his time, who obviously had little other object in the study than to indulge their love of virtuosoship.

Philippo Bonanni and Dr. Martin Lister were co-equals in the date of the publication of their works,† but in character they were men of remote eras. Lister was not less learned than the Jesuit, but of that he made no parade, and if he had drunk of the logic of the schoolmen, his tutored mind had seen its folly, for we never find him indulging in disquisitions about things inscrutable or useless. Full of the medical knowledge of the day, Lister betook himself, following the bent of his genius, to a patient anatomy of the animals which tenant and construct the shells that had won his admiration, and allowing for the state of anatomy then, we do not hesitate to say that his "Exercitationes" deserve to rank beside those of Poli and Cuvier.‡ They are replete with accurate descriptions, not unmixed it is true with error, and some things he had overlooked and mistaken, but to mark these as blots on his diligence or reputation were uncandid and unfair to him who leaves the olden ways and deviates into a new country, in which he has to open up the roads. In every page Lister proves himself a laborious and observant anatomist and naturalist; while his disquisitions and digressions relative to the leaning of his discoveries on the

* Lin. Trans. vii. 136. They but echo the words of Sir J. E. Smith in his preliminary address to the Linnæan Society. See his Tracts, p. 102.

† Lister's works were published between the years 1669 and 1697. Even the great Bentley allows that he was "learned."—See Monk's Life of Bentley, i. 130.

‡ Willis was the first who anatomized an invertebrate animal with white blood (1672): he has given an anatomy of the oyster, which, however, is very imperfect.—See Cuv. Hist. des Sc. Nat. ii. 387.

physiological questions which divided the then medical world afford the fullest proof of his acuteness, judgment, and extensive learning.* His works deserve the attentive perusal of every student in conchology, who will not fail to reap advantage from the task, even though he should go to it acquainted with the subject from recent authorities.

Lister was a true naturalist, and the first conchologist of decided eminence. His anatomical works show how clearly he understood that the structure of the animals was the main object of our study, — its only sure foundation, and its best claim on our attention, — but he was also very observant of the habits, instincts, and peculiarities of snail and shell, and was at the same time zealous to acquire an extensive and accurate knowledge of species, to which end he sacrificed much. At his own cost, and with the labour of years, he completed and published a volume of plates, which is the pride of collectors, and is prized to this day for its utility. "His figures," Dr. Maton and the Rev. Mr. Racket tell us, "both in point of number and faithfulness, are with reason still held in such high estimation, that no person attached to this branch of natural history can advance in it without the constant use of them, nor without finding them preferable for reference to many more splendid engravings which have succeeded them." † "This admirable volume," says Dr. Turton, "contains one thousand and fifty-five plates, besides twenty-one of anatomical figures, all drawn from original specimens by his two daughters, Susanna and Anna. Considering the state of natural science at the time this work was first issued, one hundred and thirty-three years since, it is impossible to contemplate this stupendous effort of genius and industry, without admiration at the grandeur of the design, and the correctness of its execution." ‡

It was Lister's intention, after the publication of this volume of plates, to have proceeded with an anatomical description of every family or genus in its proper order, if God should grant him life and leisure, but from adverse health he was not permitted to do more than to anatomize the terrestrial slugs and snails, some fresh-water Turbines, one or two

* His opinions relative to the functions of the liver in Mollusca appear deserving of more attention than they have yet received.—See the Exer. Anat. de Cochleis, p. 79, &c.

† Lin. Trans. vii. 138.

‡ Conchological Dictionary, Introd. p. xvi.—The edition by Huddesford was published at the expense of the University of Oxford. "Dignum sane viris eruditis gratoque animo præditis consilium, seu naturalium rerum studiosorum votis satisfacere, sive auctoris egregii famæ et munificentiæ monumenta hæc renovare et seræ posteritati consecrare, voluerint."—Præf. iii.

of the marine Buccina, and a part of the Bivalves. The design was worthy of the man, and is a fine example of unwearied assiduity, which naught but a genuine enthusiasm could have kept alive. If perchance, says he, a stranger should be told that this man had devoted his years to the dissection of animalcules and snails, it might provoke his contempt or laughter, unless, indeed, the dissector was another Harvey, Malpighi, or a Redi; but I do not vehemently yearn for the applause of any one, having had my reward, for these exercises which were my pleasure and delight in youth, now that I am old they are my solace. And now when I am, from a failure of sight, compelled to use the microscope, and find that by its aid I can again enjoy myself in those studies which have been long denied to the unassisted eye, I rejoice greatly.*—We do love to dwell on the character of this man. Learned in his profession, and attaining its highest honours, — for he was physician to Queen Anne, — we now see him refocating his jaded spirits in the contemplation of his collections of shells, and enjoying with a rapture which minds framed like his only feel, all their beauties and symmetries and singularities;—again we see him examining with a fatherly pride and pleasure, the drawings which his daughters, who stand beside him, had laboured to finish before the duties of the day permitted their beloved parent to retire to his ease and study,†—and at a more leisured season, we see him, bent somewhat with age and infirmities,‡ anatomizing with the zeal and skill of his youth, the creatures which he loved so well to study, now his keen eye kindling as the thought crosses him, that in this structure there was a ray which shed light on some obscurity in his own frame,—now lost in wonder at some display of a mechanism which can have but one author, while involuntarily he breathes the hymn,—"Oh altitudo! In his tam parvis, atque tam nullis, quæ ratio? quanta vis! quam inextricabilis perfectio!"

Lister then greatly advanced conchology, by rescuing it from the charge of frivolity, by an unrivalled series of illustrations of species, by many novel remarks on their habits, by a very complete history of the species of his native land, and chiefly by giving us some excellent essays on the structure and physiology of the Mollusca, which had been neglected since the time of Aristotle, for the isolated notices

* Exercit. Anat. des Cochleis, p. 2.

† "The engravings are very elegant and accurate, and were done by his two daughters, Susanna and Anne."—Da Costa, *Elem. Conchology*, p. 26.

‡ See the Preface to the App. Hist. Anim. Ang.

of a few species by Willis, Redi, Harderus, and Swammerdam, however good, had no influence on conchology, while those of Lister, are epochal.* He was fully aware too of the importance of system in this study, but he had not critically examined its real objects and use, and his classification, though elaborate, claims no praise of superiority. The *habitat* affords the character for his primary divisions or books, hence, shells are divided into the land, fresh-water, marine bivalve, and marine univalve classes; and the mode in which these are subdivided, more resembles the synoptical tables, which the French botanists now frequently prefix to their floras, constructed without any regard to the affinities of the objects they approximate, and solely intended to hunt down a species, than what is usually understood by a system in natural history.†

So far as we can collect, the manner in which the shell is formed, and its relation to the snail, occupied no part of Lister's investigations; but previous to his decease the solution of the problem was discovered by the illustrious Reaumur.‡ No experimental inquiry had hitherto been made on the subject, and the remarks in reference to it in conchological writers were scattered, vague, and hypothetical; while the opinion of better informed physiologists appears to have

* D'Argenville's character of Lister stands in a harsh contrast to that we have given. "On peut ici avancer *hardiment* que Lister, par les variations de sa méthode, a plus embrouillé l'histoire des Coquillages qu'il ne l'a éclaircie"—*Lithologie*, p. 22. Again,—"On peut dire que personne n'a jetté tant de confusion dans l'histoire des Coquillages que cet auteur, d'ailleurs bon physicien et grand médecin."—*Conchyliologie*, p. 114.—It is clear that D'Argenville was a mere amateur, and had no idea of a naturalist beyond his capacity of ticketing a cabinet. Da Costa has entered into a laboured defence of Lister against this attack, which, however unnecessary, has afforded him an opportunity of giving some curious particulars relative to Lister's great work of plates. See his Elements of Conchology, p. 28—37. Maton and Racket have unjustly praised D'Argenville for modesty, in evidence of which they tell us that his work was at first anonymous; but, though his name does not appear, it is evident from the dedication that no concealment was intended or made; and we may very fairly question the modesty of a silly author, who speaks of his own work as "un monument éternel." It is pleasing to read Deshayes' estimate of Lister's character and labours after this most injurious philippic of D'Argenville—Traité Elém. i. 42, &c.; see also Swainson's Discourse on the Study of Nat. History, p. 23.

† "Had Lister but added an index of the numerous sections, parts, and chapters, to his work, his shells would be very easily traced, though they seem more confusedly placed than in any author."—Da Costa, *Elem.* 82.

‡ "De la Formation et de l'Accroissement des Coquilles des Animaux tant terrestres qu'aquatiques, soit de mer soit de rivière," in Mém. de l'Acad. Roy. des Sc. 1709.

been that the shells were organized parts of the animal, which grew and increased with the latter by receiving nutriment and material from the body; that there was, in fact, nothing peculiar in the formation of shell, but that its growth depended, like the growth of bone, on the circulation of juices within itself, and on the assimilation and addition of new matter. Reaumur was never content with reasoning on a point which experiment alone could solve, and with his usual ability and success he instituted numerous experiments on the subject under review. They were principally made on land snails (Helix), but not restricted to them, for by confining fluviatile and marine species, both univalve and bivalve, in baskets framed so as to admit the water, and at the same time prevent the escape of the creatures, he was enabled to show that his theory was applicable to the whole class. He proved in this manner that the shell was enlarged by the deposition of calcareous matter to the edges of the aperture, and that this deposition was made in successive layers; that there was no increase from the intusception of calcareous matter, no additional increase from any action in the shell itself, but that the whole was a successive transudation from certain parts of the living tenant, to which the shell was an inorganic covering. It was objected to him that snails just issued from the egg had as many whorls as the parent, but the falsity of this observation was to Reaumur of easy proof, who found that these young had only one, or not more than a whorl and a-half; and his theory, divested of the mechanical phraseology in which some of its details are explained, remains essentially correct. Besides the establishing of this discovery so important in scientific conchology, Reaumur enriched it with much curious and interesting matter. His inquiry into the mechanism by which the limpets fix themselves so firmly, and the byssiferous bivalves spin their silken cables; his accurate description of the structure of the shell of the Pinna; and his experimental essay on the purple dye of the Buccinum, suggested to him by the excellent paper on the same subject by Mr. Cole, of Bristol, are favourable specimens of his talent for observation, and real additions to the stock of our knowledge, while they captivate us by the elegant and copious style in which they are written, and by the clearness of their details.

These labours and discoveries, and the high character of their authors, render the conclusion of the 16th, and the beginning of the 17th century, unquestionably the most interesting period in the history of conchology. Ray, who discovered the peculiar hermaphroditism of the snail, was

the intimate friend of Lister,* — Petiver and Sloane, celebrated for their museums, had entered the field ere he retired, — Balfour and Sibbald, in Scotland, were his contemporaries, and the latter his correspondent,— Poupart and Mery, two French anatomists of deserved celebrity, carried their researches in the same direction, — and Swammerdam, Leewenhoeck, and Rumphius † in Holland, — all these men were each in their way advancing conchology with a rapidity hitherto unexampled and not yet surpassed. We are apt, dazzled by this galaxy, to fix our attention too exclusively on the anatomical and physiological branches of the science; but let us not forget to note the benefit it received by the zeal of collectors, who were now importing species in great numbers from every quarter of the globe, and congregating them in museums which became celebrated throughout Europe for their richness. In England those of Petiver and Sloane surpassed all others; the collection of Sir Andrew Balfour, of the University of Edinburgh, was considerable;‡ but it was in Holland that the passion of forming cabinets of shells became most prevalent. "Rich individuals studied to outvie one another in that country, as much in the expensiveness and extent of their collections, as in the splendour of their equipages and retinue; and the sums which were

* "Eruditissimus vir et sagacissimus Naturæ operum indagator D. *Martinus Lister*, M.D. *vetus amicus noster*."—RAII, *Hist. Plant.* i. 65.

† Or rather Scheinvoet, a Dutch physician, who was the real author of Rumphius' Thesaurus. See D'Argenville's Conchyliog. p. 27.

‡ Sibbald's *Auctarium Musæi Balfouriani* "does not treat of *Testacea* exclusively, but comprehends a variety of subjects, which were contained in the collection of Sir Andrew Balfour, Knight, M.D.—a collection presented to the University of Edinburgh, and considerably augmented by the intimate friend of the donor, who described the whole in the work above-mentioned. Unfortunately for the reputation of this University among naturalists, a very small part of the collection is now remaining. 'Such,' says Mr. Pennant, 'has been the negligence of past times, that *scarce a specimen* of the noble collection deposited in it by Sir Andrew Balfour is to be met with, any more than the great additions made to it by Sir Robert Sibbald.'—(*Scotch Tour*, 1766, p. 246.) Such is too often the fate of public collections; and so slight or so transient is any respect for the laudable intentions of generous individuals towards public bodies, that common care is rarely taken to preserve from destruction what escapes the hand of peculation and robbery."—*Lin. Trans.* vii. 144.—The following Elogia on Balfour is probably from the pen of Sibbald:—

"Quæ valles, montesque tenent, vitreoque profundum
  Gurgite, quæ gremio terra benigna tulit;
Cuncta suo natura parens non invida mista
  Balfurio nosse, quæ latuere, dedit;
Quæ propriis disgesta locis pulcherrima visu
  Musæo cunctis conspicienda suo."

Analecta Scotica, Second Series, p. 153.

given for a *Cedonulli* or a *Wentletrap*, would appear too enormous to deserve belief, if such accounts were not authenticated by the most respectable writers of that day. Rumphius himself informs us in his preface to the 'Amboinshe Rariteitkamer,' that a shell described in this work cost no less than 500 Dutch florins."* In all this, of course, there was much less the love of science than the mere indulgence of a peculiar taste or rivalry that wealth or a natural disposition had engendered: and it is not easy to determine whether the good which it cannot be denied conchology derived from this zeal of collectors, was not overbalanced by the character of virtuosoism, it was calculated to fix on all its cultivators, and the new direction which it unquestionably gave to their studies.† It was to this zeal that we owe several expensive books of plates which were now prepared for the press, and published under the auspices usually of some wealthy amateur, and which, though too often occupying a prominent place in the history of conchology, have little merit excepting what they derive from the draughtsman and engraver. Hence also the repeated attempts on the part of the more studious to arrange the objects in quest after some novel or more convenient system, for without a regular specification of their contents it was evident no cor-

* Lin. Trans. vii. p. 150.—"A specimen of Conus cedonulli has been valued at 300 guineas"—*Dillwyn's Catalogue*, p. 376. "*Ammiralium* varietates nitidas *Turbinis scalaris* et *Ostreæ Mallei* æmulas nobilitavit docta ignorantia, pretiavit quam patiuntur opes stultitia, emtitavit barbara luxuria." —*Lin. Syst.* 1167. We have already mentioned the price given for specimens of Scalaria pretiosa. A single specimen of the Carinaria has been known to realise one hundred guineas.—Sowerby's Conchol. Manual, p. 98. And Chenu tells a prosy tale of a naturalist who gave a sum of between 3000 and 6000 franks for a specimen of the "Spondyle royal." The vagueness of the price, and other internal evidence, prove the story to be certainly apocryphal. —Leç. Elém. p. 105.

† They did not of course escape the observation and the lash of the satirist:—

> "But what in oddness can be more sublime
> Than *Sloane*, the foremost toyman of his time?
> His nice ambition lies in curious fancies,
> His daughter's portion a rich *Shell* inhances,
> And Ashmole's baby-house is, in his view,
> Britannia's golden mine, a rich Peru!"—YOUNG.

It is almost needless to remind the reader of the amusing papers in ridicule of the collectors in the *Spectator* and *Rambler*, but the irony of the latter in his No. 82 is more than compensated by his defence of these "much injured" men in his Nos. 84 and 85.—Lucian long before had ridiculed the men "qui savent tout, qui connaissent——la nature de l'âme des huîtres." —CUVIER, *Hist. des Sc. Nat.* i. 243.

rect idea could be imparted of the extent and worth of the collection.

In indicating the progress of "Method," however, it is necessary to go back a little. We have seen that Aristotle had three orders of Testacea, — Univalves, Bivalves, and the Turbinated, — but the class itself and these divisions were loosely defined; and the same vagueness is to be found in the writings of those authors who followed his method. Deshayes appears to consider Wotton as forming an exception, and, in speaking very favourably of his work, "De Differentiis Animalium," published so early as 1552, he says he was the first to lay the foundation of the comparative natural history of animals, and to conceive the happy idea of separating them into groups from an appreciation of their dissimilarities.* But, perhaps, Dr. Walter Charlton, Physician in Ordinary to Charles I. and II., was the first who had a full conviction of the importance of system; although his attempt to arrange the Mollusca is very faulty.† The Limaces he places with apodous insects; and aquatic animals being divided as usual into the sanguineous and exsanguineous, the remaining molluscans are arranged under two classes —viz., the mollia or molluscula and the testacea. The first embraces all the cuttles and the Lepus marinus or Aplysia; the second, the shelled tribes, whose primary sections are the same as those of Aristotle's, while his genera, usually without a definition, rest on characters of little or no value. Jean-Daniel Major, Professor of Practical Medicine in the University of Kiel, in the dutchy of Holstein, was the next to make the attempt (1675), which is pronounced by two critics, to whose opinion much deference has been shown, to be "infinitely too complicated and ramifying to admit of any useful application."‡ Sibbald, Grew, Bonanni, Lister, Langius, Hebenstreit, Tournefort, D'Argenville, and Klein are the principal who followed in their wake; but it is evident that they had all entered on their task without a previous study of what the real object and use of method

* Deshayes, Trait. Elem. i. 38.

† Onomastikon Zoikon, Lond. 1668—1671, 4to. Charlton was born in 1619; made M.D. in 1642; and soon afterwards physician in ordinary to Charles I., "he being then observed by those who knew him, to set an high value upon his own worth and parts;" he was also physician in ordinary to Charles II.; and in 1689 was chosen President of the College of Physicians. He retired about 1691 to the Isle of Jersey, "a learned and an unhappy man, aged and grave, yet too much given to romances."—Wood. Athen. Oxon. ii. 1112.

‡ We have not seen Major's work, but the view of the system given in D'Argenville's Conchyliologie, p. 112, confirms what is said in the text.

was, what principles were to guide them in framing the various sections, or what the relative bearing of these divisions on one another should be.* The division of shells primarily into Multivalve, Bivalve, and Univalve had perhaps superseded the Aristotelian, and many new divisions of secondary rate were of course invented, but they were arbitrary, founded on no common principle, either too lax or too complex to be applicable in practice, cumbersome to the memory, and clumsy in writing. To analyse these methods would be wearisome and unprofitable, — they were next to useless when promulgated, and have now no attraction even in the eyes of the pure conchologist. It is when we rise from their examination that we are in the best mood to appreciate the merits of Linnæus, and feel inclined to nod in complacent assentation to all the pæans which have been so often sung to his praise.

Linnæus having, with a tact characteristic of his genius for system, divided invertebrated animals into two great classes—*Insecta* and *Vermes*, — was less happy in his reduction of the latter into their secondary groups or orders. The testaceous Mollusca occupy one order by themselves, in which there are four sections of equal value—the multivalve, bivalve (Conchæ), the univalves with a regular spire (Cochleæ), and the univalves without a regular spire.† In each section there are several genera defined with neat precision,—the characters of the multivalves being derived from the position of the valves, —of the bivalves from the number and structure of the hinge teeth, or, in the absence of these, from a part influencing the opening of the valves,—of the Cochleæ from the unilocular or multilocular shell, but in most from the formation of the aperture; while in the last division the shape of the shell affords the means of discriminating them, excepting in Teredo which is defined "T. intrusa ligno," in evident contrariety to his principles and his better custom. The naked tribes are placed in the order denominated "Mollusca," where they stand, in "admired disorder," with radiated zoophytes, annelidans, parasitical worms, and the Echinodermata, which latter, however, are better in this strange miscellany than they were when they stood either amongst simple or multivalved shells.

In estimating the merits of this system it is not fair to

* From this observation D'Argenville offers no exemption, notwithstanding what he has said to the contrary at p. 117, &c., of his Conchyliologie.

† The expounders of Linnæus' system do not adopt this last division,—why it is difficult to say. By disregarding it they have injured the naturalness of the method.

look back from our present vantage ground and magnify its defects by a comparison with modern classifications: we are in candour to place ourselves behind its author, and looking forward, say how far his efforts have been useful or quickening.* Standing thus, we trust to offend none of his admirers when we admit that there is nothing in its principle of a novel character: the soft mollusca were previously recognized and better assorted by Charlton; and every one of the sections, and, if we mistake not, of the genera also, of the shelled tribes had been already recognized. It labours under the censure of having too small regard to the animal, a censure in some degree just, for assuredly more was known of these than the definitions of the "Systema" would lead us to suppose; and it had still less regard to the position of the groups in reference to their organical affinities.† It often associates species of dissimilar habits; and species are found in almost every genus at variance with the character of this, and where consequently the student ought not to have sought for them. The superiority of it lies in its simplicity; in the regulated subordination of all its parts; in the admirable sagacity with which the families or genera are limited; in the assumption of more stable characters for these, and for the clear distinct manner in which they are applied; in the suitableness of its nomenclature; in the invention of trivial names which gave a facility in writing hitherto unknown, and was a welcome relief to the memory; in the conciseness of the specific characters and the skill with which those characters were chosen;‡ in the regular indication of the stations which the species occupy on the globe; and in the beauty of the more extended descriptions, and the peculiar felicity of language in which the thoughts suggested by any remarkable structure in the species under review are conveyed to us.§ That merits of this kind should secure him

* The first edition of the Systema Naturæ was published in 1735, but 1758 is properly the year which gave birth to his conchological system, when the 10th edition was published. It was perfected in 1766.

† See some good remarks by Macleay on this subject in the Hor. Entom. part ii. p. 242, &c.—Mr. Gray has acutely remarked that Linnæus "referred all the animals inhabiting shells to five different genera, viz. Limax, Ascidia, Anomia, Clio, and Sepia,"—each of which is now the type of the modern classes of the mollusca,—the Limax of Gasteropoda—the Ascidia of Conchifera—the Anomia of Brachiopoda—the Clio of Pteropoda—and the Sepia of the Cephalopoda.—Syn. Brit. Mus. 50, edit. 1842.

‡ See Bosc, Coquilles, Introd. i. 30; Cuv. Hist. des Sc. Nat. iii. 24, 25.

§ The definitions of the orders *Mollusca* and *Testacea* might be quoted in illustration of this remark:—"Mollusca nuda, brachiata, vagantur pleraque per maria, cœlo resplendentia, tanquam totidem lucernis tenebricosum illuminant abyssum phosphorea, ut quod est inferius, sit tanquam superius."

something more than approbation was natural: there was much excellence in it which prejudice or jealousy only could not see, and which folly alone would have rejected; and while every collector and amateur found it easy to be understood, ready in practice, and neat in nomenclaturing their cabinets, their pursuit assumed the garb of science when they could tell the scorner that they were following the steps, and had the sanction, of a man whose genius has justly won him a place in the first rank of those whom succeeding ages continue to venerate for the good they have done in the promotion of useful knowledge.

While the eyes of almost all were turned to this northern luminary for light to guide them in their pursuit, or as an object by barking at which a few drew notice on their littleness, Jussieu of Paris, the admirer of Linnæus' genius and industry, and his correspondent, was explaining to his select but few disciples the principles of what has been commonly called the "Natural System." Jussieu's profound studies were confined to botany, but he had colleagues and contemporaries who attempted their application to conchology, and whose want of success is to be ascribed mainly to the meagreness of the anatomy of the Mollusca then attained, to the fewness of the observations made on the living species, and in part also to the imperfection of the views of the authors. Daubenton, the colleague of Buffon, so early as 1743, insisted on a knowledge of the animal as necessary to form a natural classification of shells: and in 1756, Guettard, who was the personal friend of Jussieu, not only gave his sanction to this opinion, but showed its practicability and excellence by defining, from the peculiarities of the animal and shell combined, a considerable number of the univalves, comprehending among these, in evident agreement with their relations, though contrary to general use, the slugs, the Aplysia, and the Bullæa. But the fullest attempt of this kind was made by Adanson, whose work on Senegal was published some years before Linnæus had given the last revision to his system. Impelled by an indomitable enthusiasm, Adanson visited Senegal, under many disadvantages, to examine and describe the natural productions of a tropical climate; and for this purpose he made very extensive collections in every department of nature, but of his great work the first volume only, containing the outline of his travels and his account of the

—" TESTACEA mollusca domiporta, calcareaque domuncula nobilitata, calcifica, et ipsa sæpe calcivora, insectis opposita specierum numero, magna Naturæ ludentis varietate multiplicata."—*Syst. Nat.* 1069.

shells, was ever given to the public. The character of this volume has risen with the progress of the science, and it is more valued by the conchologist of the present day than it was by the contemporaries of its author. He had some personal peculiarities—too visible in his writings—which could not fail to hurt his popularity: an austere temperament which caused him to treat his fellow-labourers with contemptuous acerbity,*—a mind that would neither bend to nor treat with respect the prejudices as he deemed them of his age,—an unflinching severity in criticising the writings of others, and a pertinacious tenacity of his own views,—while some barbarisms he attempted to introduce into the nomenclature of conchology repelled the naturalists of a too nice taste, and the very extent of his requirements from those who claimed to be naturalists operated against him, for it was not to be supposed that mere collectors or virtuosos were to enter on so difficult a path, or would be willing to allow themselves to be pushed aside as idlers, and put without the pale of the scientific circle.† That very beauty, he exclaims, which by its variety has attracted the regards of men to shells has become an obstacle to their knowledge. "La coquille seule dépositaire de cette riche parure, a fait mépriser l'animal auquel elle servoit de couverture, et est devenue seule l'objet de l'admiration de quelques naturalistes. Epris, comme les curieux, de la beauté frappante de ses couleurs, ils n'ont pas jugé que l'habitant fût digne de leurs recherches, et le difficulté de se le procurer à chaque instant, n'a pas peu contribué à augmenter leur dédain. Ils se sont donc bornés à l'examen des coquilles, ils n'en ont considéré que le forme, celle de son ouverture, ou le nombre de ses pièces; c'est d'elle seule qu'ils ont voulu tirer leurs caractères primitifs et distinctifs: de-là cette foule de systèmes aussi peu satisfaisans les uns que les autres."‡

* "In the Garden (the Botanic Garden of Paris) I have occasionally met with Mr. Adanson, whose knowledge in botany would procure him great reputation, were he less a slave to paradox and pedantry. He generally accosted me with some attack on Linnæus, sometimes calling him grossly ignorant and illiterate; and then, when I have ventured to quote Philosophia Botanica as a proof of the contrary, abusing him as scholastic."—Sir James E. Smith, *Tour on the Continent*, i. 126; and see a translation of Cuvier's interesting Memoir of Adanson in the Edinb. New. Phil. Journ. iii. 1, *et seq.*

† Adanson compares his contemporary conchologists to Scipio and Laelius, who were wont, for lack of other amusement, to pick up, like children, the pretty shells which were met with in their strolls along the Sicilian shores. "Ils n'ont traité cetta matière que comme un jeu, parce qu'ils l'ont travaillée sans soin et sans peine," &c.—*Hist. des Coquil.* pref. vii.

‡ Hist. des Coquillages, pref. v.

At a season when "Systems" were all in vogue, Adanson, with characteristic boldness, declared himself their enemy as being worse than useless, fit only to amuse triflers, certain to lead to error and alienate us from true views of the objects in question, and so easy of invention to boot that several equally good might be made by one of common experience and capacity. The history of conchology had already offered too many examples of the truth of this assertion, and he was not slack to give additional specimens in its illustration. But notwithstanding his philippic against them, Adanson, in some measure, forgot his own principles, and was little less of a systematist than those were whom he censured. Shell-fish were, according to him, distinguishable in the first place into 'Limaçons' and 'Conques;' the former were subdivided into univalves and operculated univalves, and the Conques into bivalves and multivalves; these primary families were still further divided into smaller groups from the position of the eyes in the Limaçons, and from the figure of the respiratory tubes in the Conques. Now it was a pure arbitrariness in him to fix upon the operculum as a part or organ of primary value, for there is nothing in its use or position to justify the choice, nor did he attempt, by any analysis, to show that it was a regulator of structure and habits; and it was equally arbitrary to divide the bivalves into two sections on the mere existence of a few additional pieces over the hinge, for these pieces were not proved to be an index to the animal's economy. But Adanson's services to conchology are very great,—of those its labourers who have passed in review we place him next to Lister. He has the merit of having altogether removed from the Testacea the Lepas and Balani, whose structure he saw was modelled after the type of another category; his interesting discovery of the Vermetus was a fine illustration of the shell being of itself useless as a character in natural history; and his knowledge of affinities was made evident by the acuteness which led him to approximate the Teredo to the Pholas. If not the first to point out the importance of the operculum, he was undoubtedly the first who knew its value as an index to natural relationship between genera; perhaps the first who was fully aware that the entireness or canaliculate formation of the aperture of the shell gave an insight into the habits of the snail in regard to food; the first too to point out fully the influence of age and sex in altering the shape of the shell, and more especially of its aperture; the first to describe and delineate the animal tenant of many genera; and although his attention was exclusively directed to external

characters, yet we are above all indebted to him for his strong advocacy of the maxim that the anatomy of the animal is the sole sure foundation of a rational arrangement which has in view the mutual affinities of the objects it attempts to classify, and to present them not fancifully commixed as they might be placed in a museum, but according to those characters which Nature itself has given them of affinity or dissemblance. "There is then," he says, "in shell-fish something more to consider than their shells; the snail which tenants them ought to guide our methodical arrangements, to be our only regulator, since it is the principal part, that which gives to the exterior skeleton its form, size, hardness, colours, and all the other peculiarities in it which we admire. If we attentively examine this new and forgotten race, if we consider individually the members of it, we shall discover in their manners, in their actions, in their movements and manner of life, an infinitude of curious circumstances, of facts interesting and fitted to arrest the attention of every zealous and intelligent observer; we shall perceive in the organism of their bodies a great number of parts remarkable in their structure and use; and in entering into details we shall soon be compelled to grant that this study is no childish play, but as thorny and full of difficulties as any other in the wide range of natural history."*

The example of Adanson was followed by Geoffroy who, in a history of the shells found in the vicinity of Paris, attempted to arrange them on the external anatomy of their animals; and by Müller, who described in the same manner the Mollusca of the north of Europe. The writings of Müller are still deservedly held in high estimation. They contain the descriptions of many novelties, and his descriptions of them, as well as of species previously known, are remarkable for their accuracy; they are thickly strewed with notices of the external anatomy and habits of those he had examined alive; and his style of writing is interesting, rising occasionally to eloquence. As an observer and teller of what he had observed, he claims a place among the first, but he was the discoverer of no fact in their structure or physiology of any consequence—we speak in reference to the Mollusca only; and his systematic efforts were limited and partial, although he sometimes drops a hint on the subject, which makes us almost believe that he was capable of better things, had he had courage to have made the attempt.† In relation to the Mol-

* Lib. sup. cit. pref. x.

† His Method, as detailed by himself, is as artificial as the Linnæan, and actually less in harmony with the animal organization.

lusca he clearly saw the impropriety of making the presence or absence of the shell an ordinal character; and he knew, vaguely it may be, the affinity between the bivalvular Mollusca and the Tunicata. "For what"—we translate his words—"are the Testacea but Mollusca furnished with a shell, and what are Mollusca but Testacea destitute of it? There is the most exact agreement of the tenants of the univalve shells which are called Helices with the naked slugs; and an agreement not to be overlooked of bivalves with the Ascidia; and the very error of our predecessors, who said that slugs were merely snails which had crept out of their shells, proves their near affinity. Besides the insensible but evident transition of nature from the naked Limax to the testaceous—passing from the former, which at most has the mere rudiment of an internal shell to the latter by means of the Buccinum (Limneus glutinosus), which conceals its membranous shell under a fleshy mantle, supports plainly our opinion. Therefore I do not doubt that a future age will join together the naked slugs and the shelled snails, which authors have separated into different orders." "If we wish," he writes in another place, "properly to know and discriminate natural objects, they must be considered in every point of view and in all states, so far as human imbecility will permit. The attainment of knowledge is thus indeed rendered more difficult, but at the same time more pleasant and accurate; genera indeed are multiplied, but by this way only, if by any, can species ever be determined. This is the alpha and omega of our labours, since systems and methods and genera are arbitrary and framed by the narrow limits of our knowledge. Nature acknowledges one division of created bodies only—the living and brute matter—spurning for the most part the arrangements of systematists into classes and orders, families and genera, and her productions are often so affined that their limits can never be strictly fixed. Characters derived from the interior and exterior structure of bodies deceive us not solely in the higher divisions; and even the manner of life and the mode of propagation do not afford any certain distinctions either in those races which are visible or in those which are invisible to the naked eye. There is, therefore, only one family, and one Father of all, who has marked with a constant character all species whatever from the Monad to the turret-bearing Elephant, and has distinguished Man alone with a reasonable soul." *

The celebrated Pallas was another who at this period had

* See the Præfatio to his Verm. Ter. et Fluv. vol. i. 1773.

obtained a glimpse of the true relations of the Mollusca as a class even clearer than Müller,* but he did not pursue the subject; and as his slight incidental notice, though it might have originated inquiry in a predisposed mind, was not otherwise of a nature to produce any effect, so the pains of Geoffroy and Müller were equally unproductive. The authority of Linnæus prevailed everywhere. The force of his genius having swept away all previous systems, there was no other safety for a naturalist, than to take refuge in the Linnæan ark, which floated on the surface proud amid the ruins,—the systems of his contemporaries also sinking one after another in the waters of forgetfulness; for "Method, carrying a show of total and perfect knowledge, has a tendency to generate acquiescence." His disciples were distinguished by their enthusiasm in the pursuit of nature, and their love of their master; † and the facility with which they found their discoveries were registered, and the easy nature of the discoveries which sufficed to give them a certain reputation, requiring naught but zeal, opportunity, and a knowledge of the "Systema" not difficult to be acquired, riveted their attachments.‡ In England nothing was tolerated that was not according to the letter of Linnæus: his works were a code of laws which, like an act of Parliament, was to be interpreted verbally, and the spirit of them was unseen or overlooked. Under his reforming hand, Conchology having passed "from confusion and incongruity to lucid order and simplicity," the slightest attempt to alter this order was treated as an attempt to replunge us into the chaos whence he had brought us, and further improvement or alteration was declared to be futile, since the "beauties" of the Linnæan "must perpetuate its pre-eminence." § Were it shown

* Misc. Zool. pp. 72, 73. Lug. Batav. 1778.

† "Such a kind of natural soveraignty there is, in some men's minds over others: which must needs be farr greater, when it is advanc'd by long use and the venerable name of a *Master*."—SPRAT, *Hist. R. Soc.* p. 69.

‡ "He owed his influence to various causes; at the head of which may be placed that genius for system, which, though it cramps the growth of knowledge, perhaps finally atones for that mischief by the zeal and activity which it rouses in followers and opponents, who discover truth by accident, when in pursuit of weapons for warfare. A system which attempts a task so hard as that of subjecting vast provinces of human knowledge to one or two principles, if it presents some striking instances of conformity to superficial appearances, is sure to delight the framer; and, for a time, to subdue and captivate the student too entirely for sober reflection and rigorous examination."—SIR J. MACKINTOSH.

§ Brown's Elem. of Conchology, pref. i. In a similar strain Dr. Turton writes:—"The stream of time, which is continually washing away the dissoluble fabrics of other systems, passes without injury by the adamant of

that, from the very subsidiary station the animal was made to occupy in this system, there was a fear attention should be drawn from the object most worthy of it, we were seriously told that the animal, even could it be procured, which was doubtful, would never present those "permanent and obvious points of distinction" indispensable in the application of a system meant to be practical. Wherein does the animal differ, it was asked in a tone of triumph, signifying that reply was impossible,—"wherein does the animal differ from an unshapen mass of lifeless matter when coiled up within its shelly habitation? And how are its natural shape and appendages to be examined, but by the knife of an anatomist?"* Were it proved, what indeed was most palpable, that species of opposite habits and habitations were huddled together under a common head, it was answered that to derive characters from such particulars was contrary to axiom and unphilosophical; and if it were demonstrative that the class of Testacea, as a whole, was constituted of heterogeneous disparates,—as for example when Pallas indicated the difference between this class and the Serpulæ,—what then? Nature gloried in variety and oppositions, and was herself systemless,† as if it were possible to believe that He, who made every thing in wisdom and order, had shook His creatures from His hand, with the same wanton unordered profusion that the poet has represented the jocund May, flinging the flowerets from her teeming lap. Such were the futile reasons by which this System was upheld, and so firm was its despotism that, until within these twenty years, there was little or no relaxation on its hold of public opinion; and its evil effects are too evident in the superficialness of the productions which emanated from this school.

Even in France the Linnæan system soon became little less predominant under the leading of Bruguiere, but the regard the French paid to it was of a less slavish character than it

Linné." *Some Account of the Life of Sir C. Linné*, p. 42. The Rev. Mr. Burrow is equally imaginative in his language, and grandiloquent in his prophetical judgment.—*Elements*, pref. vi. &c.

* Da Costa, Elem. Conchology, 7—24; Lin. Trans. vii. p. 177; Brown's Elements, p. 10.

† "Nature does not seem to have observed *any system*, and an artificial one will ever be attended with anomalies. Whatever method therefore most readily leads to the subject under investigation, is certainly the best, and in this case it is of small importance where that subject is placed, or how far it is removed from others to which it seems to bear a general resemblance."—Maton, in *Pulteney's Life of Linnæus*, p. 238.—Sir J. E. Smith also allows himself to talk of the "irregularities of Nature," as an apology for some inconsistencies in the zoological works of Linnæus.—*Tracts*, p. 136.

had assumed in Britain. Bruguiere, though a Linnæan in principle, carried forward in some degree the system of his master by intercalating many new and obviously necessary genera; and he was otherwise a conchologist of higher attainments than any England could at that period boast of.* He cannot be said to have promoted Conchology in any very sensible degree, but he made no effort to arrest it, or detain the science at the stage where Linnæus had left it. Nor indeed is it perhaps possible to stop the march of any, however trivial the branch of science, to perfection. Like the operations of Nature in her living productions ever tending to maturity, there are periods of acceleration and delay, and causes may for a season induce a sickly weakness that waits long for a remedy, but come at last this will. Conchology was now in her sickly time,—nevertheless in a state of constant advancement. Ellis, Baster, Bohadtch, Pallas, Müller, Forskäl, Solander, and Otho Fabricius, all of whom might have seen Linnæus in the flesh, and were his immediate successors, drew attention to the naked molluscans in particular, whose curious variety was enticing and provocative to further quest; Herissant, Scopoli, Bruguiere, and Olivi, described many species with their animals, and entered too into physiological questions which it was worthy reasonable men to solve; Knorr, Davila, Martini and Chemnitz, Schröter, Born, Pennant, Da Costa, and Martyn, set forth at intervals volumes of figures more numerous in species, and more correct than had been hitherto attempted; and the minute or

* He made a distinct class of the Star-fish and Sea-Urchins, under the name of "Echinodermata;" but it is a proof of his ignorance of its real relations and connections, when he made that class the connecting link between the soft mollusca and the testacea.—*Tab. Syst. des Vers*, p. vi.

Mr. Swainson asserts that Bruguiere borrowed his improvements from Mr. George Humphrey, F.L.S., the chief commercial conchologist of his time. Mr. Humphrey published his work in 1797—"Museum Calonnianum"—"wherein he arranged the Testacea upon an entirely novel and very remarkable plan,"—a plan which "served as the main foundation, although unacknowledged, for the subsequent system of Bruguiere, if not of Lamarck and Cuvier." "It was, therefore, not in France, but in England, that the revolution against the meagre conchological school of Linnæus first originated."—*Treat. on Malacology*, p. 15. Mr. Swainson's enthusiasm in the cause of a too much neglected conchologist has surely led him greatly to overestimate his merits. Mr. Humphrey did not introduce any new principle into his system; and, so far as I can discover, his sole merit was in indicating several good genera. These were not defined. Lamarck, and more so Bruguiere, may have derived some hints from Humphrey; but it seems very absurd to suppose that Cuvier was in any way influenced by his labours. "In common hands, analysis stops at the species or the genus, and cannot rise to the order or the class." So it was with Humphrey and Bruguiere; and so it was not with Cuvier.

microscopic species, which notwithstanding their littleness, have played a most important part in the revolutions of our globe, were well illustrated in the great work of Soldani, and more partially in the less laborious works of Plancus, Boys and Walker, and of Fichtel and Moll. Yet this array of names only proves a wider spread of the study,—the students may have been, and we think were, mediocrists,—many of them were simply iconographists and collectors.* We can remember no discovery by which to distinguish the period, for the development or improvement of an artificial system, the accumulation of species, and their more accurate discrimination, though points of considerable importance, are not sufficiently so to mark an era. Perhaps the most curious and interesting discovery that was made in it is, that of the capability of the snail to reproduce its tentacula, eyes, and head, when these have been cut off,—the phenomena of which singular reintegration were amply elucidated by the experiments of Spallanzani, Bonnet, and others.

The first to raise us from this enchained slumber was Cuvier. Before this great naturalist entered the field, Poli, a Neapolitan physician, had indeed anatomized with admirable skill the bivalved mollusca of his native shores, and had constructed a new arrangement of them from the characters of the animal alone, but partly from the political position of Europe, partly from the very expensive fashion in which Poli's work was published, and its consequent extremely limited circulation, and in part also from the partial application of his system and its didactic character, the erroneousness of his general views, and the novelty of his nomenclature,—we cannot trace its influence either as diffusive or propulsive of conchology.† The result of Cuvier's labours was happily very different. In 1788, when he was scarcely nineteen years of age, circumstances fixed Cuvier

* It is most especially necessary to except from this remark John Hunter, but his labours and views were not published, and were not appreciated. "John Hunter was a great discoverer in his own science; but one who well knew him has told us, that few of his contemporaries perceived the ultimate object of his pursuits; and his strong and solitary genius laboured to perfect his designs without the solace of sympathy, without one cheering approbation."—D'Israeli's *Literary Character*, i. 146. See Abernethy's Physiological Lectures, p. 193, for a list of the Mollusca anatomized and exhibited in Hunter's Museum, also p. 217, 263.

† I borrow the following synopsis of Poli's classification from Deshayes, never having seen Poli's work: it is limited to the Conchifera, which are named

MOLLUSCA TESTACEA SUBSILIENTIA.

Family I. *Mollusks with double siphons and a foot.*—Genera—Hypogea, Peronæa, Callista, Arthemis, Cerastes.

for a time at Caen in Normandy. His sojourn on the borders of the sea induced him, already an enthusiast in natural history, to study marine animals, more especially the mollusca, and the anatomies of them, which he now made, conducted him to the development of his great views on the whole of the animal kingdom. With unwearied zeal he collected the materials which were at no distant date to become the basis of a classification which run through all its details in a harmonious parallelism with the development of organization, so that the student of it, when in search of the name and place of the object in his hand, was necessitated simultaneously to acquire a knowledge of its principal structural peculiarities, on which, again, as Cuvier beautifully explained, all its habits in relation to food, to habitation, and to locomotion were made dependant. The Linnæan system of avertebrated animals, even in its primary sections, rested on a single external character. The Insecta were *antennulated*, and the Vermes were *tentaculated* avertebrates. Had the character been constant or even general, it might have had some claim for adoption, but to a want of constancy was added the fundamental defect of its inappreciable influence over the organisms of the body. Cuvier's object being to give us not merely a key to the name, but to make that key open at the same time a knowledge of the structure and relations of the creature, such arbitrary assumption of a character was to him useless. After innumerable dissections had made him familiar with many structures, and after a careful consideration of the respective value of characters, as shown in their constancy and influence on the economy of the species, Cuvier resolved to divide the animal kingdom, not as hitherto into two, but into four principal sub-kingdoms, drawing their lines of separation from differences exhibited in the plan on which their muscular, their nervous, and their circulating systems were formed. "There exist in nature," he says, "*four* principal forms, or general plans, according to which all animals seem to have been modelled, and the ulterior divisions of which, whatever name the naturalist may apply to them, are but comparatively slight mo-

Family II. *Mollusks with a single siphon and a foot.*—Genera—Loripes, Limnæa.
Family III. *Mollusks with a single siphon.*—Genera—Chimæra, Callitriche.
Family IV. *Mollusks with a single abdominal siphon and no foot.*—Genus—Argus.
Family V. *Mollusks without a siphon but with a foot.*—Genus—Axinea.
Family VI. *Mollusks without a siphon and without a foot.*—Genera—Daphne, Peloris, Echion, Criopus.

difications, founded on development or addition of certain parts, which do not change the essence of the plan." Of these forms the Mollusca furnish the second, of which the essential character is derived from the peculiar arrangement of the nervous system, consisting of some ganglions scattered, as it were, irregularly through the body, and from each of which nerves radiate to its various organs. As there is no skeleton, so the muscles are attached to the skin, which forms a soft contractile envelope protected, in many species, by a shell. The greater number possess the senses of taste and sight, but the last is often wanting. "Only one family can boast of the organ of hearing; they have always a complete system of circulation, and organs peculiarly adapted to respiration; those of digestion and secretion are nearly as complicated as the same organs in vertebrated animals." * The sub-kingdom, characterized and limited by these important features, is next divided into six classes, the characters of which are mostly derived from the organs of locomotion or others not less influential. Thus the Cephalopods bear their feet and arms like a coronet round the summit of the head; the Pteropods swim in their native seas by fin-like oars; and the Gasteropods crawl on the belly by means of a flat disk or sole. Reaching now tribes among whom the organs of motion are less developed, and accordingly less influential on their manners, Cuvier resorts to others. Thus the fourth class is named Acéphales, because it is strikingly distinguished by the want of head and amorphous form of its constituents; the Brachiopods are equally acephalous, but near the mouth they have two fringed fleshy organs which simulate feet; and the Cirrhopods have several pairs of sub-articulated fringed feet, in addition to a multivalved shell of a peculiar construction. The orders of these classes, when the class admits of further subdivision, rest upon distinct differences in the structure and position of the branchiæ or respiratory organs; and when we reflect a moment on the paramount necessity of these to the animal, and their necessary co-adaptation to its locality and wants, it is scarcely possible to conceive that a happier choice could have been made.

We have already explained at sufficient length the Cuvierian system; and enough has been now said to show its vast superiority to all that had preceded it. The solidity of its basis is proved by the fact that the numerous recent discoveries in this department have not shaken it, or altered its principles. The lower divisions and sections have been im-

* Memoirs of Cuvier by Mrs. Lee, p. 107—109.

proved and increased, the definitions have been rendered more technical and precise, but every method which has followed, both in its outline and main features, are modifications, and often very slight ones, of Cuvier's. "Multa fiunt eadem, sed aliter;" and the assent of M. Sander Rang to this decision, you may consider as a confirmation of its truth. This excellent naturalist says, "Ce qui fait bien connaître l'excellence de cette distribution, c'est qu'elle n'a point paru un seul instant insuffisante aux progrès de la science et aux nombreuses découvertes qui ont été faites dans ces derniers temps, et qu'elle n'a pu être avantageusement remplacée par celles qui ont été imaginées depuis. Il est même à remarquer que lorsque des naturalistes ont cherché à en créer de nouvelles, ils n'ont fait à peu près que changer la nomenclature; ou bien ils ont adopté une nouvelle série de caractères pour désigner les mêmes classes et les mêmes ordres, ou, enfin, changé entre elles les différentes acceptions des mots de classe, d'ordre, etc., de sorte que les mêmes animaux se sont encore, à peu de chose près, groupés comme auparavant."*

* Manuel des Mollusques, p. 18.

LETTER XXVII.

THE HISTORY OF SYSTEMS OF CONCHOLOGY FROM THE PUBLICATION OF CUVIER'S SYSTEM TO ITS COMPLETION.

I HAVE, in my last letter, sketched rather than written the history of Conchology from its first origin to the end of the last century; but I must trace its future progress with a more tedious pen, and travel, moreover, with a guide through its cross and reticulated byepaths. For the names which claim a place in this history are many, and being often those of contemporaneous men, I might find a difficulty in assigning each his place,—the works of many of them being placed far beyond my reach by the expensive manner in which they have been published; nor does my library furnish the various editions even of those which have been most influential. I shall, therefore, assume Deshayes for my guide;* who, so far as my means enable me to judge, is both an honest and a learned one.

It was in 1798 that Cuvier published this his first arrangement:

MOLLUSCA.

	Genera.	
CEPHALOPODES	Sepia,	Argonauta,
	Octopus,	Nautilus.
GASTEROPODES. G. naked . .	Limax,	Phyllidia,
	Tethys,	Scyllæa,
	Aplysia,	Thalides,
	Doris,	Lernæa.
	Tritonia,	
G. testaceous		
A. *shell multivalve* . .	Chiton.	
B. *shell univalve, not spiral*	Patella.	
C. *shell turbinate, the aperture entire*	Haliotis,	Bulimus,
	Nerita,	Bulla,
	Planorbis,	Turbo,
	Helix,	Trochus.

* Traité Elémentaire de Conchyliologie, avec l'application de cette Science à la Géognosie. Par G. P. Deshayes, 2 vols. 8vo. 1839. This work, which I cannot too highly commend, is indispensably necessary to the Conchologist. It is not yet completed.

D. *shell turbinate, the aperture channelled* . . .	Murex, Voluta, Strombus, Oliva, Cassis, Cypræa, Buccinum, Conus.
ACEPHALES	
A. *A. naked*	Ascidia, Biphores,
B. *A. conchiferous and apodous, the shell inequivalve* .	Ostrea, Anomia, Spondylus, Pecten. Placuna,
C. *A. conchiferous and with a foot, the valves equal, and the lobes of the mantle open in front*	Lima, Tellina, Perna, Cardium, Avicula, Mactra, Mytilus, Venus, Pinna, Chama, Anodonta, Arca. Unio,
D. *A. conchiferous and with a foot, the valves equal, the shell gaping at both ends, the lobes of the mantle close in front*	Solen, Pholas, Mya, Teredo.
E. *A. conchiferous and apodous, furnished with two fleshy ciliated spiral tentacula*	Terebratula, Orbicula. Lingula.
E. *A. testaceous, furnished with a number of jointed and ciliated tentacula arranged in pairs*	Anatifa, Balanus.

There are, you perceive, three primary sections of equal value, and their characteristic names are for the first time introduced into science. In preceding systems the Cephalopods were considered to be constituents of the order of soft worms, while the Nautilus and Argonauta were members of the order Testacea. The division of the Gasteropods into two subsections from the absence or presence of a shell was not a happy one; and the unnatural result was to remove the Limax far away from its near relative the Helix. The claims of the Thalides and Lernæa to a place in this order were subsequently proved to be unfounded. The arrangement of the testaceous Gasteropods is borrowed partly from Linnæus and partly from Adanson; and Poli professedly supplied the characters on which Cuvier distributed the Bivalves into their families. He was more original and acute when he embodied with them the naked Acephales, although it is probable that he may have found the hint of their

affinity in the writings of Müller, or even in the "Systema Naturæ;" as it is certain he yielded himself to the influence of Linnæus in retaining the Balani and Anatifæ in the class.

Lamarck, already eminent amongst botanists, was at this time elected professor of zoology to the Museum of Natural History, and immediately began his efforts to reform the classification of the animals whose history it was his duty to expound. He is considered by his countrymen to have possessed the talent for method in a higher degree than any naturalist saving Linnæus; and there appears to be some justness in this appreciation of his character. His systematical essays are always based on accurate and extensive knowledge; and the foundations of his divisions are laid on characters of organization which must influence more or less the animal's economy. These divisions are, at the same time, uniformily defined with remarkable precision and neatness, so as to be well adapted to the purposes of the nomenclaturist. A happy example of this is found in his primary division of the animal kingdom into vertebrate and invertebrate animals,—terms so well chosen that they have become household words with us all, displacing from scientific nomenclature their Aristotelian equivalents, sanguineous and exsanguineous, which the progress of physiology had shown to be no longer applicable.

In his first essay, of the date of 1799, Lamarck did not deviate from his predecessors in any thing essential. He divided the order Testacea into univalve, bivalve, and multivalve shells. The univalves were either unilocular or multilocular; the bivalves were irregular or regular; and the multivalves were as Linnæus left them. But in 1804 a new edition of his method bore very evident marks of Cuvier's influence upon its author. The method is as follows:

MOLLUSCA.

I. Cephalous Mollusca.

Naked . . .	Swimmers—Gen.: Sepia, Loligo, Octopus, Lernæa, Firola, Clio.
	Gasteropods—Gen.: Laplysia, Dolabella, Bullæa, Tethys, Limax, Sigaretus, Onchydium, Tritonia, Doris, Phyllidia, Chiton.
Testaceous.	
1. Shell univalve unilocular not spiral covering the animal	Gen.: Patella, Fissurella, Emarginula, Concholepas, Crepidula, Calyptræa.

2. Shell univalve unilocular spiral sheathing the animal.

* *Aperture emarginate, or channelled at its base.* Gen.: Conus, Cypræa, Ovula, Terebellum, Oliva, Ancillaria, Voluta, Mitra, Columbella, Marginella, Cancellaria, Nassa, Purpura, Buccinum, Eburna, Terebra, Dolium, Harpa, Cassis, Strombus, Pterocera, Rostellaria, Murex, Fusus, Pyrula, Fasciolaria, Turbinella, Pleurotoma, Clavatula, Cerithium.

** *Aperture entire and without a canal at its base.* Gen.: Trochus, Solarium, Turbo, Monodonta, Cyclostoma, Scalaria, Pupa, Turritella, Ianthina, Bulla, Bulimus, Agathina, Limnæa, Melania, Pyramidella, Auricula, Valvata, Ampullaria, Planorbis, Helix, Helicina, Nerita, Natica, Testacella, Stomatia, Haliotis, Vermicularia, Siliquaria, Aspergillum, Carinaria, Argonauta.

3. Shell univalve multilocular sheathing or enclosing the animal. — Gen.: Nautilus, Orbulites, Ammonites, Planulites, Nummulites, Spirula, Turrulites, Baculites, Orthocera, Hippurites, Belemnites.

II. Acephalous Mollusca.

Naked. — Gen.: Ascidia, Biphores, Mammaria.

Conchiferous.

1. Shell equivalve with or without accessary pieces. — Gen.: Pinna, Mytilus, Modiola, Anodonta, Unio, Nucula, Pectunculus, Arca, Cucullæa, Trigonia, Tridacna, Hippopus, Cardita, Isocardia, Cardium, Crassatella, Paphia, Lutraria, Mactra, Petricola, Donax, Meretrix, Venus, Venericardia, Cyclas, Lucina, Tellina, Capsa, Sanguinolaria, Solen, Glycimeris, Mya, Pholas.

2. Shell inequivalve of two or more valves, of which the principal are unequal.

* *Principal valve tubular.* Gen.: Teredo, Fistulana.

** *Bivalve, the valves unequal.* Gen.: Acardium, Radiolites, Cama, Spondylus, Plicatula, Gryphæa, Ostrea, Vulsella, Malleus, Avicula, Perna, Placuna, Pecten, Lima, Pedum, Pandora, Corbula, Anomia, Crania, Terebratula, Calceola, Hyalæa, Orbicula, Lingula.

*** *Multivalve and no hinge.* Gen.: Anatifa, Balanus.

This arrangement is inferior to the previous one of Cuvier in several respects; but the division of the Mollusca into two primary sections from the character of the head, is both convenient and physiologically correct, for it indicates corresponding modifications in the development of the nervous system. External habit likewise proves the value of the division. There is a wide difference in the physiognomy of a naked cephalous mollusk, and in that of a naked acephalous one, marking indisputably the superior faculties and structure of the former; and the shell of the testaceous mollusk that is headed is univalve or imbricate, while that of the acephala is uniformly bivalvular. But the chief merit of this artificial method is the creation of many new genera. Bruguiere had proposed sixty-one genera; Lamarck here raised the number to 126; and so well were they limited and true in nature, that they have been all retained in the most approved systems that followed.

But Cuvier was the moving spirit that led to every useful reform. In a series of admirable essays published in the "Mémoires du Museum,"* he skilfully developed the anatomy of the principal genera of the Mollusca, and rendered his descriptive details interesting by the ease and perspicuity of his style, by his mastery of his subject and over all that had been done before him, and by his critical acumen in questionable points. His eloquent lectures told more immediately on his pupils, who arose around the great master in zealous numbers; and to two of them we are indebted for the publication of those lectures, which to this day declare the solidity of the fame they had so early procured him. In the volume published in 1800 there is the following synopsis of his method of classifying the Mollusca at that period:

* Subsequently collected together, and published in a quarto volume, with the title "Mémoires pour servir à l'histoire et à l'anatomie des Mollusques, par M. le Chevalier Cuvier." Paris, 1817. It is essential to the library of the Conchologist.

MOLLUSCA.

I. The Head encircled with tentacula which serve the purposes of feet.

Fam. I. Cephalopodes.

* *Naked*—Genus: Sepia. ** *Testaceous*—Genera: Argonauta, Nautilus.

II. The Head distinct, the animal gasteropod.

Fam. ii. Gasteropodes.

* *Shelless, or the Shell internal.*—Genera: Doris, Phyllidia, Thetis, Limax, Testacella, Sigaretus, Aplysia. ** *Shelled.* § Shell multivalve. Genus: Chiton. §§ Shell conical. Genus: Patella. §§§ Shell turbinate. (*a*) Aperture entire. Genera: Haliotis, Nerita, Turbo, Vermetus, Trochus, Bulla, Helix. (*b*) Aperture emarginate or effuse. Genera: Voluta, Ovula, Cypræa, Conus, Terebellum. (*c*) Aperture canaliculate. Genera: Murex, Strombus, Buccinum.

III. No Head.

Fam. iii. Acephales.

* *The mantle membranous or coriaceous, and naked.* Genera: Ascidia, Biphores, Firoles, Thalia.

** *The mantle furnished with a shell:*—§. Mantle open in front; no articulated tentacula nor ciliated arms. (*a*) Inequivalve. Genera: Ostrea, Lazare, Spondylus, Placuna, Anomia, Peloris. (*b*) Equivalve, a foot for creeping, no siphons. Genera: Anodonta, Unio. (*c*) Equivalve, a foot for spinning, no siphons. Genera: Lima, Perna, Avicula, Mytilus, Pinna. (*d*) Siphons to the mantle for a vent and respiration. The foot often fitted for spinning. Genera: Tellina, Cardium, Mactra, Venus, Donax, Chama, Arca. §§ Mantle open at one end for the passage of the foot and prolonged into a double siphon at the other. Genera: Solen, Mya, Pholas, Teredo. §§§ Mantle open in front, but neither foot nor siphons; two ciliated spirally coiled arms. Genera: Terebratula, Lingula, Orbicula. §§§§ Mantle open in front; no foot nor siphons. A tube proceeding from the body, and horny articulated tentacula arranged in pairs. Genera: Anatifa, Balanus.†

† The *genera* of Cuvier are the co-equals of the *families* of other naturalists. I do not quote his *sub-genera*, for they were confessedly borrowed from other authors.

It is difficult for us to perceive wherein Cuvier had benefitted from Lamarck in drawing up this arrangement, as Deshayes affirms, for its merits and improvements depend exclusively on the choice of characters for the main sections; and he had recourse to Lamarck only for the indication of the sub-genera. We need not tarry to point out the improvements here effected, for they will be obvious on a comparison with the previous synopsis; nor need I detain you with any notice of the crude and useless compilations of Bosc and of Denis Montfort—the latter the very Baron Munchausen of conchologists. M. de Roissy deserves, however, honourable mention, for his popular and well-executed continuation of the volumes of Buffon contributed to diffuse a knowledge and taste for our science. He neither invented a method nor created genera, but he was the first who attempted to complete Cuvier's system by intercalating, in their fit places, the genera of Lamarck. He annotated each of them with concise explanations; he occasionally set forth new views of their relations, and he added useful notices of the animal inhabitants,—all done with clearness and sagacity. Cuvier had just established a new order under the name of Pteropodes, embracing the genera Clio, Hyalæa, Pneumoderma, and the Firoles; and M. de Roissy hastened to adopt the order, placing it, at the suggestions of Cuvier, between the Cephalopods and Gasteropods. Henceforth the Hyalæa was withdrawn from the vicinage of the Terebratula and Anomia, where both Cuvier and Lamarck had misplaced it, before the former became acquainted with its anatomy.

While Cuvier was thus pursuing his researches into the structure of the Mollusca, Lamarck's activity carried him in a different direction to study the fossils of the environs of Paris. His memoirs on these contain the descriptions of many new species, and are enriched with valuable observations on each genus. He discovered some new genera, amongst which we may specify the Clavagella, important as a link in connecting the Aspergillum with the acephalous mollusks that possess a calcareous tube. A zealous collector who had, with much perseverance, brought together the fossils of Grignon and other places, aided the work in placing his rich and beautiful collection at Lamarck's disposal. M. Defrance was the first, and then the only, naturalist who interested himself, in a scientific manner, with the fossils of the basin of Paris; and it is to his preliminary labours that the authors of the Geology of that basin are indebted for the well-determined lists of fossils on which their theory of its production is based.

In 1809 Lamarck published his "Philosophy of Zoology." My estimate of the work is much below that of Deshayes, but I agree with him in thinking that it had an influence in directing the attention of zoologists to higher matters of speculation, than was deemed by many of them to be within their cognisance; and it treated matters which were more strictly so with a wider scope, and with a bold disrespect of established opinion, more characteristic of the period than of the individual. The work contains a new edition of his classification of the Mollusca, which are made to stand at the head of invertebrate animals; rather, however, because this position favoured Lamarck's hypothesis of organic development, than because of the influence of Cuvier's anatomies. The novelty in the method is his introduction of a section, borrowed from the Botanists, which he called a family,—a very convenient, and indeed important, innovation which has not since been departed from. In his disposition of the Acephales there is nothing new to remark; but he follows Cuvier in dividing the Cephales into Pteropodes, Gasteropodes, and Cephalopodes. Into the latter order he now also unfortunately introduced the microscopic multilocular shells, as well as the Carinaria and the Argonauta. But I need not enter into any further analysis of this method, for, in 1812, it was republished with considerable modifications, necessitated by the discoveries which Peron and Lesueur had made in the Australasian seas, and by the continued fructifying labours of Cuvier. Lamarck introduced then into the testaceous Acephales their ordinal divisions of *Monomyaires* and *Dimyaires;* and although, at a first glance, it may seem to be of little consequence whether an animal is connected to its shell by one or by two muscles, it is actually far otherwise,—the resulting organic modifications being felt not only in the form and structure of the shell, but even in the nervous system, and thence also in the economy of the mollusks. These divisions have, therefore, never disappeared from conchological systems, although some exceptions to their literal accuracy have been pointed out; and the characters on which they rest are happily of ready apprehension in general. The secondary divisions of this class were now derived from the presence or absence of a byssus, the equality or unequalness of the valves, the position of the ligament, the form of the hinge, and the variations in the locomotive organs.

The cephalous Mollusca were divided into five sections, viz., 1, the Pteropods; 2, the Gasteropods; 3, the Trachelipods; 4, the Cephalopods; and 5, the Heteropods. The third and the fifth were new; and the latter was placed above

the Cephalopods, to whom they were inferior in organization, because, forsooth, M. Lamarck chose to believe that Nature, in her successive production of the different classes of animals, could not pass from a lower to a higher one, except by first falling back on her steps, — by, as it were, degrading herself to animate an order of weak and anomalous beings wherein she, for a time, nursed her energies to be enabled to take the forward leap in structural organism which fate was ever impelling her to make. You may find the doctrine indicated by the greatest of Scottish bards, when he sung of Nature trying her apprentice hand in a coarser clay before she attempted her master-piece of creation; and you may indulge your national partiality, if you choose, in tracing back the theory of self-development to this tuneful source. The doctrine of the development of the flower from the leaf draws its origin from a not more illustrious poet.

The Pteropods were embraced in a single family, into which the new genera established by Peron and Lesueur were introduced, with the exception of the Carinaria and Pterotrachea, which were considered to be heteropod; and of the Callianires, which were remanded back to their station in the radiated subkingdom. The old order of Gasteropods was dismembered, and greatly curtailed in its demesne, by the elevation of the Trachelipods to a coequal rank; but you will at once perceive the unnaturalness of this proceeding, when I tell you that the slug is a Gasteropod, and the snail a Trachelipod, — genera which certainly are at least ordinally connected. The two orders do, in fact, pass into each other by a series of transition species, so that it is frequently a question to which order some of them ought to be related; and hence it follows, that the more or less separation of the foot from the ventral aspect of the body does not entail on the structure of the animal changes of sufficient importance to afford ordinal characters.

Of the reduced Gasteropods we find their families established on a diagnosis derived from the position and nature of the breathing organs. Some can live and breathe in water only, others only breathe the air; and important modifications in the respiratory apparatus accompany these habits. The distinguishing characters of the families then is superior to that of the orders, — involving an error fatal to any system. It is the same, but to a less marked degree, with the distribution of the Trachelipods. They are first partitioned into two suborders from the absence or possession of a fleshy siphon, evidenced on the shell by its aperture being entire or canaliculate or effuse; and the character, as you may remem-

ber, is one of such high consideration that it might be taken as the distinction of the highest order, were it not that Lamarck again fixes on still more influential organs for lower divisions, viz., the respiratory organs, and their fitness for aqueous or aerial respiration. The form of the columella, the length of the siphonal canal, the shape of the right lip of the aperture, the depth of the emargination, &c., furnish him with good characters for the families.

The Cephalopods, in this new arrangement, have three primary sections, — the multilocular, the unilocular, and the naked. This is the same as they were in 1809; but the Carinaria was properly withdrawn from the unilocular cephalopods, and in place of five there were now established nine families, and a greater number of genera. These reforms were made principally in the microscopic chambered shells, which, we now know, are not molluscan; but Lamarck benefited Conchology by distinctly isolating the family Ammonites, which he characterized and separated from those Cephalopods that have the Nautilus for their representative.

As Lamarck, in his subsequent publications, retained the principles and main features of his system of 1812, it will be most convenient to present it to you in this place with his last improvements, as these are detailed in his "Histoire Naturelle des Animaux sans Vertebres," * — a great work indispensable to every naturalist, and which must be daily in your hands. I know of no other that can be compared with it in point of utility to the practical conchologist, nor of any other that has had a more salutary influence over the progress of his study.

Starting from the assumed principle that animal existences have proceeded from a common origin,— the lowest entity in creation, — and that they have, self-willed, gradually complicated and elevated their structure, a certain stage is reached where disturbing forces operate to direct the creative energy into two distinct roads, each leading upwards to comparative perfection. Infusory animalcules lead on, in one road, to the polypes; and these again directly to the radiated classes; and, by a bye-path, to the acephalous naked mollusca. The latter constitute a separate class, which Lamarck first of all denominated the Tunicata. They are not polypes, yet still less are they mollusca, for many kinds of articulated animals occupy the wide interval between them, wherein nature tarried, as it were, with the ascidian orders, seemingly uncertain as to her future course. The Tunicata are non-sentient, the Mollusca are sentient or instinctive

* Seven vols. 8vo., Paris, 1815—22.

animals; and that the former are naturally wide apart from the latter, Lamarck thinks is proved by the following considerations: — 1. Because the condition of existence of the Tunicata, their generally attached state, their internal structure, and their peculiar outward form, are all alien to what we observe in the Mollusca, none of whom have their organs exactly paired and symmetrical. 2. Because their position amongst the Mollusca rests upon the attribution of functions to organs whose real nature and office are only hypothetically determined. 3. Because the relative position and structure of the branchial and alimentary cavities are dissimilar to those of the Mollusca. The supposed branchial sac of the Tunicata, for example, has an external aperture which admits the food into it, while what is said to be the real mouth is placed at the bottom of this same cavity, — a disposition of parts unexampled amongst molluscans, even of the lowest testaceous acephales, in which the branchiæ are very differently constructed. 4. Because Nature doth not seem ever to have placed the branchiæ in the alimentary canal itself; and hence a trellis-work of nervures crossing each other at right angles to form quadrangular meshes is probably not vascular, but rather the result of muscular fibres fitted by this disposition to contract and dilate the so-called branchial sac: all blood-vessels depart from a straight course only by making a curvature. 5. Because true branchiæ are only to be observed in animals which have a circulation, — the existence of which in the Tunicata is not proved; and to admit the existence of a circulation in the Botryllidæ and Pyrosoma would seem to be ridiculous. 6. Because the existence of a brain, of a heart, of a liver, and of generative organs, all essential to a molluscan, cannot be proven in the Tunicata, where, in these respects, all is conjecture and arbitrary determinations.—Some of Lamarck's statements in this argument have been disproved, and the others have been deemed invalid by so many naturalists that we have all along treated the Tunicata as members of the molluscous class, and hence the reason that I introduce Lamarck's classification of the latter with his arrangement of the Tunicata.*

Class TUNICATA. (August, 1816.)

Order I. TUNICIERS RÉUNIS OU BOTRYLLAIRES. Animals agglomerated, always united together, constituting a common mass by their union, and apparently having a communication with each other.

* See note at the conclusion of this letter.

(1) *Animals attached to marine bodies.*

* No peculiar systems formed by the disposition of the animals in the common mass which they inhabit.

(*a*) *A single opening (or mouth or anus) apparent externally for each individual.*

Aplidium. Eucœlium.

Synoicum.

(*b*) *Two openings (a mouth and vent) apparent externally for each individual.*

Sigillina. Distomus.

** Animals forming peculiar isolated systems by their disposition in the common mass which they inhabit.

(*a*) *Animals arranged in several concentric circles occupying the common mass.*

Diazoma.

(*b*) *Animals forming peculiar scattered systems, and arranged in each system around a central cavity.*

Polyclinum. Polycyclus.

Botryllus.

(2) *Animals floating with their common mass in the bosom of the sea.*

Pyrosoma.

Order II. Tuniciers libres ou Ascidiens. Animals separate, either isolated or clustered, but without mutual communication, and not forming a compound mass.

Salpa. Ascidia.

Bipapillaria. Mammaria.

Class CONCHIFERA. (July, 1818.)

Order I. Conchifères dimyaires. There are at least two adductor muscles, the impressions of which on the inner surface of the valves are separate and lateral.

(1) Shell regular, and generally equivalve.

(*a*) Shell in general gaping at the sides when the valves are closed.

* *Conchifères crassipedes.* Lobes of the mantle entirely or partially coalescent in front; foot thick and posterior; gape of the shell often considerable and always more or less marked.

Les Tubicolées. Les Pholadaires.

Les Solenacées. Les Myaires.

** *Conchifères tenuipedes.* Lobes of the mantle scarcely or not at all united in front; foot small and compressed; gape of the shell often inconsiderable.

† Ligament internal, with or without the complication of an external ligament.

Les Mactracées. Les Corbulées.

†† Ligament solely external.

Les Lithophages. Les Nymphacées.

(*b*) Shell close at the sides when the valves are shut.

*** *Conchifères lamellipedes.* Foot flattened, lamellar, not posterior.

(2) Shell irregular, always inequivalve.

Les Conques. Les Cardiacées.
Les Arcacées. Les Nayades.
Les Camacées.

Order II. CONCHIFÈRES MONOMYAIRES. One adductor muscle only; and its impression on the valves is single and subcentral.

(1) Shell transverse and equivalve.

Les Bénitiers.

(2) Shell either longitudinal or inequivalve.

(*a*) Ligament marginal, prolonged along the margin, and sublinear.

Les Mytilacées. Les Malléacées.

(*b*) Ligament concentrated in a short space under the beaks, always recognisable and not tubiform.

Les Pectinides. Les Ostracées.

(*c*) Ligament either unknown or forming a tendinous tube under the shell.

Les Rudistes. Les Brachiopodes.

Class MOLLUSCA. (June, 1819.)

Order I. PTEROPODES. No foot to creep upon, nor arms to drag themselves along, or therewith to seize their prey. Two opposite and similar fins adapted for swimming.

Order II. GASTEROPODES. The body straight, never spiral nor enveloped in a shell that can contain it. A muscular foot united to the body throughout its length and forming a ventral disk to creep upon.

Order III. TRACHELIPODES. The body twisted spirally, detached from the foot, and always enclosed in a spiral shell. The foot free, flattened, attached to the inferior base of the neck, and fitted for creeping.

Order IV. CEPHALOPODES. The body contained inferiorly in a sacciform mantle. Head protruding from this sac, crowned by non-articulated arms, which are furnished with suckers and encircle a mouth armed with two horny mandibles.

Order V. HETEROPODES. No arms in coronet on the head; no foot under the belly or throat to creep upon. One or several fins, not paired nor regular in their position.

Order I. PTEROPODES.

There is no subdivision of this order which contains the genera Hyalæa, Clio, Cleodora, Limacina, Cymbulia, and Pneumodermon.

Order II. GASTEROPODES.

I. SECTION. Branchiæ, whatever their position, raised either in filaments, or laminæ, or combs or tufts. They breathe water only. (*Hydrobranches.*)

(*a*) Branchiæ external, placed above the mantle, either on the back or on the sides, and never in a special cavity.
Les Tritoniens.

(*b*) Branchiæ external, placed under the margin of the mantle; and disposed in a longitudinal series either around the body or on one side only, but not in a special cavity.
Les Phyllidiens.
Les Semi-Phyllidiens.

(*c*) Branchiæ placed in a special cavity on the back, situated forwards near the neck.
Les Calyptraciens.

(*d*) Branchiæ placed in a special cavity towards the posterior part of the back, and covered either by the mantle or by an opercular shield.
† No tentacula. Les Bulléens,
†† With tentacula. Les Laplysiens.

II. SECTION. Branchiæ creeping, under the form of a vascular network, on the walls of a special cavity, the aperture of which the animal opens and shuts at pleasure. They breathe the atmosphere only. (*Pneumobranches.*)
Les Limaciens.

Order III. TRACHELIPODES.

I. SECTION. T. without a prominent siphon, and in general breathing by a hole. The most part of them are herbivorous and furnished with jaws. Shell with the aperture entire, having at its base neither a dorsally directed emargination nor canal. (Les *Phytiphages.*)

* Trachelipods breathing the air. Shell spiral, even, not distinctly nacred.

(*a*) Inhabitants of the land.

Les Colimacées.

with 4 } tentacula.
with 2 }

(*b*) Inhabitants of the water, but ascending the surface for air to breathe. Shell with the margins of the aperture never reflected.

Les Lymnéens.

** Trachelipods breathing water only. Branchiæ projecting, in the form of filaments, laminæ, or tufts, into the branchial cavity. Shell often nacred, and often also roughened with protuberances on the surface.

(*a*) Shell fluviatile, operculate, the left lip not imitating a semipartition.

† Shell with the lips of the aperture separate.

Les Melaniens.

†† Shell with the lips of the aperture continuous.

Les Peristomiens.

(*b*) Shell fluviatile or marine, the left lip resembling a semipartition.

Les Neritacés.

(*c*) Shell marine, the left lip not imitative of a semipartition.

† Shell floating on the surface.

Les Ianthines.

†† Shell not floating, the aperture very widely open; no columella.

Les Macrostomes.

††† Aperture not particularly open, with plaits on the columella.

Les Plicacés.

†††† No plaits or folds on the columella.

§ Margin of the aperture continuous and circular.

Les Scalariens.

§§ Margins of the aperture separate.

Les Turbinacés.

II. Section. T. with a projecting siphon to conduct the water of respiration to the branchiæ. All are marine, zoophagous, destitute of jaws, and furnished with a retractile proboscis. Shell spiral, enveloping, with an aperture either canaliculate, or emarginate, or effuse at the base. (Les *Zoophages*.)

a. Shell with a more or less elongated canal at the base of the aperture, of which the right lip undergoes no change from age.

Les Canalifères.

b. Shell with a more or less elongated canal at the base of the aperture, the form of the right lip altered at maturity, and with a sinus on the lower part.

Les Ailées.

c. Shell with a short canal ascending posteriorly, or with an oblique emargination, semi-canaliculate at the base of the aperture, the semi-canal being directed towards the beak.

Les Purpurifères.

d. No canal at the base of the aperture but a subdorsal sinus, and folds on the columella.

Les Columellaires.

e. Shell without a canal, but the base of the aperture emarginate or effuse; and the volutions of the spire large, compressed, and so convolved that the last covers up almost entirely the others.

Les Enroulées.

Order IV. CEPHALOPODES. (August, 1822.)

I. SECTION. C. POLYTHALAMES. Shell multilocular, completely or partially enveloped, and enchased in the posterior part of the body of the animal, often with organic adhesion.

* Shell multilocular with even septa. (The margins of the septa are simple, and do not imprint sinuous and jagged sutures on the internal wall of the shell.)

(1). Shell straight or nearly so: not spiral.

Les Orthocérées.

(2). Shell partially spiral, the last whorl continued in a straight line.

Les Lituolées.

(3). Shell semi-discoid, the spire eccentric.

Les Cristacées.

(4). Shell globular, spheroidal or oval, with the whorls of the spire enveloping or with cells united together in the mantle.

Les Sphérulées.

(5). Shell discoid with a central spire and cells radiating from the centre to the circumference.

Les Radiolées.

(6). Shell discoid with a central spire and cells which do not radiate from the centre to the circumference.

Les Nautilacées.

** Shell multilocular with septa jagged and foliaceous on the margins.

Les Ammonées.

II. SECTION. C. MONOTHALAMES. Shell unilocular, external, and containing the animal.

Genus Argonauta.

III. SECTION. C. SEPIARES. No shell, either internal or external. A solid, free, cretaceous, or horny body is contained in the interior of most of these animals.

The Genera are Octopus, Loligo, Loligopsis, and Sepia.

Order V. HETEROPODES.

There is no section in this order, nor families; and the genera are

Carinaria. Pterotrachea.
Phylliroë.

You will observe, in this outline of Lamarck's system, the conciseness and precision with which every divisional limit is charactered; and the same precision with greater, yet not with less distinct, fulness, he carries into the definition of his well-selected genera, which are, again, illustrated with a copious body of species characterised with rare excellence: and, in this view alone, worthy to be studied as models for your own guidance. Hence the main cause of the popular reception of Lamarck's system, for these advantages adapted it to the use of collectors, and of those who were engaged in naming collections. You will often have to use it, and it may interest you to know that blindness came with the publication of the volumes that contain it, to deprive the author of that sense most of all indispensable to a naturalist. He found his assistant—the endeared substitute of a lost sense—as Lister had done—in his daughter. She devoted her youth to the promotion of the studies and fame of her parent, now stricken with infirmity and age; and so he finished a work on which his future reputation must mainly rest.

Before Lamarck had completed this system, Cuvier had given to his the form and features which it was hereafter to retain. This was in 1817; for, when republished by him in 1830, it underwent no material alteration. There can be no doubt of its superiority in its classical and ordinal sections, and even in the indication of the principal families; but Cuvier neither attempted, nor seemed much to care, to place families, genera, and species in that relationship and degree to each other in which we please ourselves in dreaming that they were brought into existence, and stand in

Nature's heraldry.* Nor did he define families (his genera) nor genera (sub-genera) neatly; and he merely indicated a few typical species,—leaving this work for others to perform. He claimed the merit of the design and architecture of the building, but its passages, and rooms, and closets were sketched in chalk to permit the substitution of a more convenient plan and neater furniture, if any one could furnish it.

And so it was. It was scarcely published before reforms were suggested, for authority had been discarded, and science participated in the oscillatory spirit of the times which saw in every innovation a merit. The new systems came from Blainville and M. de Ferussac,—the former the successor of Lamarck,—the latter a rich and learned amateur. M. de Ferussac's was first published in 1822; and the man at once made evident his weakness and vanity by the invention of a new series of absurd and lengthy names, which he himself could scarcely hope ever to see introduced into science. He vainly hoped, too, to amend the classification of the animals so strangely designated by mixing up in one the systems of Cuvier and Lamarck; and the attempt was a failure, for every alteration was made for the worse. Thus the Cirrhopods had been removed from the category of Mollusca by Lamarck, but they were restored by M. de Ferussac, who yielded here to the authority of Cuvier, just where it ought to have been resisted; and in the restoration he misplaced them in the system. So also with his misalliance of the Brachiopods; but I deem it unnecessary to detain you with any exposition of the views of this author, for I cannot trace any influence they have ever had on the progress of Conchology. He did, indeed, call more especial attention to a small group of terrestrial Gasteropods which have an operculated shell; and as this character is correlative with some peculiarity in the organisation of the animals, he had some reason to assume it as sufficient for the establishment of a new order amongst the pulmonated mollusks. The order, which he names "Pulmones opercules," embraces the genera Cyclostoma and Helicina. There is still a difference of opinion in relation to its value.

M. de Blainville came well prepared for his task. He is eminently distinguished for his knowledge and attainments in anatomy, physiology, and natural history, and he had directed especial attention to the molluscous tribes. But his method of them has never got into use, partly from its com-

* Of his classification Cuvier says himself, "Cette distribution des mollusques m'appartient entièrement, ainsi que le plupart de ses subdivisions du second degré."—*Reg. Anim.* iii. 6.

plexity, partly from its anatomical character, and partly because of its harsh and new nomenclature,—a great and just bar to the easy reception of any system. Blainville's appears to have been invented in 1816, but by a curious accident it was not published until 1825, for his "Manuel de Malacologie et de Conchyliologie" was written for a British Encyclopædia, and, being mislaid by Dr. Leach, was lost for some years. In the meantime, however, M. de Blainville gave an outline of a method in his "Principes d'Anatomie comparée," published in 1822;* and there is something so curious and novel in his general distribution of the animal kingdom, when taken in connection with certain modern theories as to a natural system, that I shall copy out for your perusal (page 541) such portion of it as has an immediate reference to our subject. You may observe that, as if in ridicule of his predecessor's self-elevating hypothesis, the Mollusca are made to proceed out from the vertebrated fishes, with a widely intervening chasm of separation between them;—Nature being made both to leap and to descend from perfection to imperfection, which she can do, believe me, just as easily as she can ascend on the contrary direction. You may also remark that a new principle is introduced into the arrangement of the Mollusca derived from the condition of their reproductive organs,—a principle of questionable utility even were its physiological correctness admitted, because it is recondite and not to be easily seized upon; and not being sufficiently impressive in the animal's economy, it is found to put too far asunder genera evidently more nighly affined. I quite agree with Mr. Swainson in his objection to the use of internal anatomy in classification.† External structure is just as important for this purpose; and we know that it is in fact an index to interior organisation, which it is surely unnecessary to specify in the outline or definitions of a method.

I take the subjoined outline of De Blainville's system from his Manuel,‡ in which the characters of every division, from the type to the genus, are given with elaborate care.

Type—Malacozoa.

Class I. CEPHALOPHORA = Cephalopods.

Order I. Cryptodibranchiata=Sepia, Lin.

* De l'Organization des Animaux; ou, Principes d'Anatomie comparée, par M. H. M. Ducrotay de Blainville.—Paris, 1822, 8vo. The first volume only has been published.

† Prel. Discourse on Nat. History, p. 84.

‡ One vol. 8vo. with an atlas. Paris, 1825.

Tableau indiquant comment le série des animaux se fait des Ostéozoaires aux Actinozoaires, par une double ligne des A. invertébrés.

SOUS-RÈGNE I.

ARTIOZOAIRES ....ou.................. A. PAIRS.

Type I.

Osteozoaires .... ou A. vertébrés.
Sous-Type I. .... Vivipares.

Homme.

Pilifères	.... Mammifères.
Sous-Classe I.	.... Monodelphes.
Sous-Classe II.	.... Didelphes.
Sous-Type II.	.... Ovipares.
Pennifères	.... *Oiseaux.*
Squammifères	.... *Reptiles.*
Nudipellifères	.... *Amphibiens.*
Pinnifères	.... *Poissons.*
Anosteozoaires	.... ou A. invertébrés.

Type II.		Type III.
Entomozoaires	Sous-Type. Malentozoaires.	... Malacozoaires.
Hexapodes		...... *Cephalophores.*
Octopodes		...... *Dioïques.*
Decapodes		...... *Hermaphrodites.*
Heteropodes		...... *Monoïques.*
Tetradecapodes ...		...... *Acephalophores.*
Myriapodes	Nematopodes. Polyplaxiphores.	...... *Palliobranches.*
Chetopodes.		...... *Lamellibranches.*
Apodes		
Annelidiaires.		Heterobranches.

SOUS-RÈGNE II.

ACTINOZOAIRES .... A. RAYONNÉS.

Family 1. Octocera, with 8 tentacular appendages; the rim of the suckers muscular.

,, 2. Decacera, with 10 tentacular appendages, 2 eccentric and longer; the rim of the suckers spinous.

Order II. Cellulacea. Blainville remarks that it is very probable that the animals which form the shells of this order are very different from those of the Spirula and Argonauta.

Family 1. Spherulacea. Shell more or less spherical.

,, 2. Planulacea. Shell very depressed, not spiral, chambered, with septa visible on the exterior.

,, 3. Nummulacea. Shell discoid or lenticular, the whorls concealed, cellular, without a siphon.

Order III. Polythalamacea. Ex. Nautilus, Spirula.

Family 1. Orthocerata. Shell conical or slightly compressed, straight or somewhat arched, the septa sinuous or simple, perforated with a siphon.

,, 2. Lituacea. Ex. Spirula.

,, 3. Cristacea.

,, 4. Ammonacea. Ex. Ammonites.

,, 5. Nautilacea. Ex. Nautilus.

,, 6. Turbinacea.

,, 7. Turriculacea.

Class II. PARACEPHALOPHORA. Gasteropoda.

Sub-class I. P. dioica.

Sexes separate, the male and female distinct individuals.

Section I. *Respiratory organs, and the shell non-symmetrical; the shell almost invariably revolving in spiral from left to right.*

Order I. Siphonobranchiata. Organs of respiration formed by one or two comb-like branchiæ situated obliquely on the anterior part of the back, and contained in a cavity having its upper wall prolonged into a canal more or less elongated and attached to the columella.

Family 1. Siphonostomata = Murex, Lin.

,, 2. Entomostomata = Buccinum, Lin.

,, 3. Angyostomata. *An operculum. Ex. Strombus, Conus. ** No operculum. Ex. Terebellum, Oliva, Voluta, Cypræa.

Order II. Asiphonobranchiata. Organs of respiration formed by one or two comb-like branchiæ situated obliquely on the anterior part of the back, and con-

tained-in a cavity of which the upper wall is not prolonged into a canal, but there is sometimes an appendage or inferior lobe to do its office. Shell very variable in form, the aperture entire and operculate; the operculum horny or calcareous, and proportionable to the aperture.

Family 1. GONIOSTOMATA = Trochus, Lin.

,, 2. CRICOSTOMATA = Turbo, Lin.

,, 3. ELLIPSOSTOMATA. Shell variable in form, ordinarily smooth, aperture oval longitudinal or sometimes transverse, closed with a horny or calcareous operculum. Ex. Melania, Rissoa, Phasianella, Ampullaria, Helicina, &c.

,, 4. HEMICYCLOSTOMA = Nerita, Lin.

,, 5. OXYSTOMA. Genus: Ianthina.

Subclass II. P. MONOICA.

Sexes distinct, but the same individual both male and female.

SECTION I. *Respiratory organs and shell (when it exists) non-symmetrical.*

Order I. PULMOBRANCHIATA. Organs of respiration retiform or aerial, clothing the floor of the cavity, placed obliquely from left to right on the origin of the back of the animal, and communicating with the circumfluent fluid by a small round orifice, pierced on the right side of the swollen margin of the mantle.

Family 1. LIMNACEA. Ex. Limnæa, Planorbis.

,, 2. AURICULACEA. Genera: Pedipes, Auricula, Pyramidella.

,, 3. LIMACINEA. * Ex. Bulimus, Pupa, Helix. ** Testacella, Limax.

Order II. CHISMOBRANCHIATA. Organs of respiration aquatic, or branchial pectinate, situated at the anterior part of the back in a large cavity communicating with the circumfluent fluid by a wide oblique and anterior fissure. Mouth without a tooth, but furnished inferiorly with a long lingual ribbon. Shell or none, or internal or external, very depressed, with a very large entire aperture and no columella.

The genera are Coriocella, Sigaretus, Cryptostoma, Oxinoe, Stomatella, Velutina.

Order III. MONOPLEUROBRANCHIATA. Organs of respiration branchial, situated on the right side of the body and covered more or less by the operculiform mantle, in which there is often a Shell, plane, or more or less

spiral, with a very wide and entire aperture: tentacula or none, or rudimentary, or earlike.

Family 1. SUBAPLYSIACEA. Two or four tentacular appendages: orifices of the generative organs approximate and without an intermediate furrow. Gen.: Barthella, Pleurobranchus, Pleurobranchidium.

Family 2. APLYSIACEA. Four tentacular earlike appendages: sexual orifices distant and united by a furrow. Gen.: Aplysia, Dolabella, Bursatella, Notarchus, Elysia.

,, 3. PATELLOIDEA. Body depressed and covered by a large external non-symmetrical patelliform shell. Gen.: Ombrella, Siphonaria, Tylodina.

,, 4. AKERA. Body more or less globular, gasteropod, divided into two parts, the anterior often furnished with lateral lobes: head indistinct, without tentacula or with rudimentary tentacula. Ex. Bulla, Bullea.

SECTION II. *Respiratory organs and shell* (*when it exists, which is rarely*) *symmetrical.*

Order I. APOROBRANCHIATA. Body variable in form but always furnished with natatory appendages in pairs and lateral; no foot; organs of respiration often inconspicuous.

Family 1, THECOSOMATA. Genera: Hyalæa, Cleodora, Cymbulia, Pyrgo.

,, 2. GYMNOSOMATA. Genera: Clio, Pneumoderma.

,, 3. PSILOSOMATA. Genus: Phylliroe.

Order II. POLYBRANCHIATA. Organs of respiration branchial, in numerous filaments or tufts disposed symmetrically and on the exterior of each side of the body, which is naked.

Family 1. TETRACERATA. Branchiæ simple, filamentous. Gen.: Glaucus, Laniogerus, Tergipes, Cavolina, Eolida.

,, 2. DICERATA. Branchiæ arbuscular. Gen.: Scyllæa, Tritonia, Thethys.

Order III. CYCLOBRANCHIATA. Organs of respiration branchial, more or less arbuscular, collected symmetrically near the vent which is on the median line of the posterior part of the body. Gen.: Doris, Onchidoris Peronia.

Order IV. INFEROBRANCHIATA. Organs of respiration branchial, in the form of lamellæ under the projecting

margin of the cloak; body naked, oval, more or less tubercular.

Gen.: Phyllidia, Linguella.

Order V. NUCLEOBRANCHIATA. Organs of respiration in the form of symmetrical filaments grouped with the digestive organs in a nucleus situated on the superior and, generally, the posterior part of the back; the skin thick, naked, and mucous. Shell symmetrical, more or less spiral longitudinally or from behind forwards, and very thin.

Family 1. NECTOPODA. A ventral foot compressed into a rounded swimmer. Gen.: Pterotrachea, Carinaria.

,, 2. PTEROPODA. A winglike appendage on each side of the body for swimming. Gen.: Atlanta, Spiratella, Argonauta.

Subclass III. P. HERMAPHRODITA.

Every individual of the species alike and unisexual. Shell simple, covering, rarely a little spiral, symmetrical or not, non-operculate.

SECTION I. *Organs of respiration and shell symmetrical.*

Order I. CIRRHOBRANCHIATA. Organs of respiration filamentous, seated on two sessile lobes above the neck. Gen.: Dentalium.

Order II. CERVICOBRANCHIATA. Organs of respiration in a large cavity above the neck, with a wide opening in front.

Family I. RETIFERA. Organs of respiration retiform on the floor of the branchial cavity. Gen.: Patella.

,, 2. BRANCHIFERA. Organs of respiration two large equal combs. Gen.: Fissurella, Emarginula, Parmaphorus.

SECTION II. *Organs of respiration and shell non-symmetrical.*

Order III. SCUTIBRANCHIATA. Organs of respiration aqueous, and covered by a subspiral or patelliform shell.

Family 1. OTIDEA. Respiratory organs on the left side. Gen.: Haliotis, Ancylus.

,, 2. CALYPTRACEA. Branchiæ above the origin of the back. Ex. Crepidula, Calyptræa, Capulus, Hipponyx.

Class III. ACEPHALOPHORA = Acephales, Cuv.

Order I. PALLIOBRANCHIATA = Brachiopodes, Cuv.

Section I. *Shell symmetrical.* The genera are—

Lingula. Terebratula.
Thecidea. Strophonema.
Plagiostoma. Dianchora.
Podopsis.

Section II. *Shell non-symmetrical, irregular, attached.*

Orbicula. Crania.

Order II. Rudista. The genera are—

Spherulites. Hippurites.
Radiolites. Birostrites.
Calceola.

Order III. Lamellibranchiata = Acephales testaces, Cuv.

Family 1. Ostracea. The Genera are Anomia, Placuna, Harpax, Ostrea, Gryphæa.

„ 2. Subostracea. Gen.: Spondylus, Plicatula, Hinnites, Pecten, Pedum, Lima.

„ 3. Margaritacea. Gen.: Vulsella, Malleus, Perna, Crenatula, Inoceramus, Catillus, Pulvinites, Gervillia, Avicula.

„ 4. Mytilacea. Gen.: Mytilus, Pinna.

„ 5. Polyodonta. Gen.: Arca, Pectunculus, Nucula.

„ 6. Submytilacea. * Species with an epidermis, nacred, fluviatile. Anodonta, Unio.—** Species without a distinct epidermis, not nacred, and more or less pectinate: marine.—Cardita.

„ 7. Camacea. * Shell irregular. Chama, Diceras, Etheria. ** Shell regular. Tridacna, Isocardium, Trigonia.

„ 8. Conchacea. Section 1. Regular with distant lateral teeth. Cardium, Donax, Tellina, Lucina, Cyclas, Cyprina Mactra, Erycina. Section 2. Regular without separate lateral teeth. Crassatella, Venus. Section 3. Irregular. Venerupis, Coralliophaga, Clotho, Corbula, Sphæna, Ungulina.

„ 9. Pyloridea. Section 1. Ligament internal. Pandora, Anatina, Thracia, Mya, Lutricola.—Section 2. Ligament external and swollen. Psammocola, Soletellina, Sanguinolaria, Solecurtus, Solen, Solemya, Panopæa, Glycimera, Saxicava, Byssomya, Rhomboides, Hiatella, Gastrochæna, Clavagella, Aspergillum.

,, 10. ADESMACEA. Gen.: Pholas, Teredina, Teredo, Fistulana, Septaria.

Order IV. HETEROBRANCHIATA=Acephales sans coquilles, Cuv.

Family 1. ASCIDIACEA = Ascidia, Lin.

Tribe 1. Simple Ascidia. Gen.: Ascidia, Bipapillaria, Fodia.

Tribe 2. Compound Ascidia.—Gen.: Pyura, Distoma, Botryllus, Synoicum.

,, 2. SALPACEA.

Tribe 1. Simple. Gen.: Salpa.

Tribe 2. Compound. Gen.: Pyrosoma.

Sub-type. MALENTOZOARIA.

This division embraces two very dictinct classes. The first named NEMATOPODA is coequal with the genus Lepas of Linnæus, and the class Cirrhopodes of Cuvier; and as they are now considered to be constituents of the class Crustacea, I pass over their arrangement. The second class is named POLYPLAXIPHORA, and is instituted for the sole reception of the Chitons, multivalve shells with whose general appearance you are now familiar. The class, according to De Blainville, is very distinct from any other in the series of the animal kingdom, and apparently is the medium of transition from the cephalous mollusca to the Chetopodes,—an order in the Entomozoa or annulose worms. This opinion is founded on the kind of articulated shell which covers the back of the Chiton, and on the circumstance that the vent is not lateral and approximated to the mouth, as in other Mollusca, but perforated at the opposite extremity to the mouth, and in the median line, as it is in all Annelidans.

Incapacitated by his blindness, Lamarck had called upon M. Latreille to undertake his duty of delivering the lectures on the history of avertebrated animals at the Jardin du Roi; and the result was a system of the Mollusca by this great entomologist, in which the sexual peculiarities of the class assume the first rank, as if Latreille had imbued himself with the fancies of Oken concerning the predominancy of the sexual organs in the Mollusca. The system was published in 1825, a little before the appearance of Blainville's Manual, but subsequently to the publication of his classification in the "Dictionnaire des Sciences Naturelles." The following outline may give you some idea of it. Firstly the invertebrate animals are divided into the Cephalidiens and the Acephala. The Cephalidiens correspond to the

merely sentient or instincted animals of Lamarck, and embrace the molluscous and the conchiferous classes, which he proposes to call mantled animals—animalia penulata. The Molluscan race are divisible into two branches, the phanerogamous and the agamous or cryptogamic. The first copulate; the second have the sexual character masked and fecundate themselves. The phanerogamous are either finned or finless. There are two classes of the finned section, the CEPHALOPODS and PTEROPODS; and the finless are all GASTEROPODS.

The Cephalopods divide themselves into two orders. 1. the *Decapods*, with two families, one embracing the multilocular shells, and hence named Polythalama; the other named Enterostea, and represented by the genera Sepia and Loligo. The second order or *Octopods* has also two families,—a shelless one (Acochlides) for the Octopus; and one with its fine unilocular shell (Cymbicochlides), to receive the Ocythoe, Argonauta, and Bellerophon.

The class Pteropoda has two orders, *Megapterygia* and *Micropterygia*. In the first the swimmers are large. One family of them has a distinct head (Procephala), as instanced in Limacina and Clio; the other (Cryptocephala) has the head inconspicuous, with branchiæ separate from the swimmers; and the genus Hyalæa alone represents it. The second order has small swimmers, and the body has no shell; and a single genus, Pneumodermon, makes evident its insignificance.

The GASTEROPODA are either hermaphroditical or diœcious; and in both sections there are branchiferous and pulmonated mollusca. The order *Nudibranchia* introduces the first series, which seems to be connected with the Pteropods by the genus Carinaria, the first of the Nudibranches. These have three families named, from the position and form of the respiratory organs, Urobranchia, Seribranchia, and Phyllobranchia. This order is followed by that of the *Inferobranchia*, and this again by the *Tectibranchia*, of which one family (Tentaculata) has, and the other (Acera) has no tentacula. The order *Pulmonea* succeeds, and these are either naked (Nudilimaces), or terrestrial and cochleated (Geocochlides), or aquatic and shelled (Limnocochlides.)

There are only two orders of diœcious Gasteropods. The *Pneumopoma*, or operculated terrestrial mollusca, embraces the family Helicinides and Turbicina, each represented by a single genus. The *Pectinibranchia* is, on the contrary, a very extensive order with not less than eighteen families, divided into two very unequal sections according as the shell is ex-

ternal or internal, and hence named Gymnocochlides and Cryptocochlides. The limits of the families are circumscribed by characters derived from the shell, and possess no peculiar merit to detain us in particularizing them.

The second branch or cryptogamous mollusca are distributed into three classes. The first named PELTOCOCHLIDES embraces the *Scutibranches* and *Cyclobranches* of Cuvier. The second is the BRACHIOPODA, which are either pedunculated or sessile, the character being considered as of ordinal value. The third is the CONCHIFERA, which are classified on the principles of Cuvier, whose families are, however, elevated into the rank of orders. Of these there are four named respectively *Patulipalla*, *Biforipalla*, *Triforipalla* and *Tubulipalla*, names which have some merit in so far as they indicate the condition of the mantle upon which they are characterized.*

On a comparison of these systems you will remark, as their leading principles, that in Cuvier's the character of the *subkingdom* is derived from the peculiar modification of the nervous system; the character of the *classes* from the organs of locomotion, and from the possession of a head; the character of the *orders* from the respiratory organs, and, in the Acephales, from the presence or absence of a shell; and the character of the *families* from external variations of minor importance but always influential over habits,—in the Acephales testacés principally from the form of the mantle. Lamarck divides the race at once into two *sections* from the presence or absence of a head; and the latter rest their claim to *classical* distinction on the possession of a bivalve shell; deriving their *ordinal* characters from having one or two adductor muscles to close it; and their *families* from peculiarities in the form of the foot. The true or cephalous mollusca are divided into *orders* from the organs of locomotion; the next *sections* from the habitat and its co-relative organical peculiarities; the *subsections* from the respiratory organs; and the *families* from various sources;—but in the Cephalopods the diagnoses of the primary divisions is derived from peculiarities in the formation of the shell. Blainville again has a type and sub-type,—the latter dependent on an approach to an annular division of the body. The character of the *classes*

* Familles naturelles du Règne Animal. Paris, 1825. 8vo.

† There is more meant than expressed in the following sentence, written by Cuvier under the provocation of seeing his nomenclature changed unnecessarily: "M. de Lamarck dans son dernier ouvrage, a fait de mes Acéphales testacés, sa classe des Conchifères; et M. de Blainville son ordre des Acéphalophores lamellibranches; *mais c'est toujours la même chose.*"—*Reg. Anim.* iii. 117.

is placed in the development of a head; of the *subclasses* in the nature of the procreative sources; of the *orders* from the branchiæ; and of the *families* from a comprehensive compendium of all external features. There is, therefore, a great dissimilarity in these systems, which may entitle them to be considered as original inventions to a certain extent; but I cannot otherwise persuade myself than that those of Lamarck and De Blainville derive their origin and being from Cuvier; † while that of Latreille, inferior to any of them, must be considered as merely the emanation of a system-making mind exercising itself on a subject which was known to it only as presented through the writings of others.

These great and learned naturalists were contemporaneous men, and they gave to Conchology in France an active and living spirit at a period of time when, in other countries, it showed only feeble symptoms of vitality. Italy, to whose naturalists some would, as I think, unjustly,* trace back the rise of the impulsive wave that moved the stillness the wand of Linnæus had commanded, was overrun by the conqueror and spoiler; and the few learned works of her professors were nearly as unknown to the public as the illuminated MSS. of her monastic libraries. Brocchi limited his researches to the fossil shells of the subapennine hills; and Delle Chiaje published only detached Memoirs on the Mollusca of the Bay of Naples, in rivalry of those of Cuvier. The north of Europe evidenced even less interest in our science. M. Schumacher, a Dane, published in 1817, a child's plaything under the name of a system of Conchology, in which no regard was paid to any part of the animal beyond its shell; and in which radiated animals found themselves ill at ease by the side of Cirrhopods, red-blooded worms, and cold-blooded molluscans. In 1820, on the contrary, Dr. Schweigger furnished the students of Germany with an excellent manual of Natural History embracing a succinct exposition of Cuvier's views in malacology, with notes derived from other trustworthy sources, or personal observation. As Dr. Schweigger has introduced some new names into conchology, and as his definitions are short and pithy, and embrace well-selected characters, I shall copy it out for you in the language he himself employs.

* Latreille states the case fairly: "MM. Poli, le Baron Cuvier, le Chevalier de Lamarck, le Baron de Férussac et de Blainville sont, de tous les naturalistes de nos jours, ceux qui ont le plus illustré cette division zoologique; mais c'est surtout au second que nous sommes redevables d'une véritable méthode naturelle."—*Fam. Nat.* 152.—From Latreille's high estimate of Ferussac's labours I dissent entirely.

MOLLUSCA.

Mollusca animalia invertebrata inarticulata, circulatione humorum completa, medulla nervosa simplici. Corpus membrana laxa (pallio) utplurimum cinctum: aut testaceum aut nudum.

Ordo I. M. Brachiopoda. Mollusca pallio aperto bilobo. Branchiæ filamentosæ, superficiem loborum internam coronantes. Pes nullus, sed brachia pectinata carnosa retractilia. Testa bivalvis, aut sessilis aut pedicello sessili affixa.

Ordo II. Acephala. Mollusca aquatilia capite nullo, ore inermi, branchiis utplurimum foliaceis. Hermaphrodita. Coitus nullus.

A. Testa calcarea nulla, sed corpus substantia accessoria aut membranacea aut gelatinoso-cartilaginea plus minusve vestitum.=Tunicata, Lam.

1. *Testa membranacea aut gelatinosa—cartilaginea cum corpore incluso non nisi margine ostiolorum cohærens.*—Ascidiæ Tethydes, Sav.

Corpus utplurimum affixum (*Tethyæ*, Sav.) raro liberum. (*Luciæ*, Sav.)

a. Animalcula plura, involucro aut tubo communi conjuncta, singula sacco branchiali, in fundo os excipiente munita.

† Anus animalculorum orificio branchioli approximatus. Orificium dentatum. Animalcula in substantia gelatinoso-cartilaginea distributa. Stirps affixa. Gen.: *Polyclinum*, Cuv. non Sav.

a. Animalcula, in substantia gelatinoso-calcarea sparsa; corpus singulorum filo postico appendiculatum, quo animalcula conjuncta aut solitaria. Gen.: Sigillina, Eucœlium, Didemnium, Aplidium, Distoma.

b. Animalcula radiatim conjuncta. Gen.: Synoicum, Diazona, Polyclinum, Sav.

†† Orificium animalculorum branchiale tentaculatum, anus oppositus, in tubum centralem apertus, orificio nudo munitum. Gen.: Polycylus, Botryllus, Pyrosoma.

β. Animalcula solitaria aut juxtapositione fortuita cohærentia.

a. Stirps libera. Gen.: Mammaria, Bipapillaria.

b. Stirps affixa. Gen.: Ascidia, Lin.

2. *Substantia gelatinoso-cartilaginea cum tota corporis superficie cohærens.* ASCIDIÆ THALIDES, Sav.

Gen.: Biphora, Brug. = Salpa et Dagysa, Gmel.

B. Testa bivalvis aut multivalvis. Valvulæ ligamento cartilagineo hiantes, in fossa cardinis dentati aut edentuli recondito. Musculi aut musculorum testam claudentium foveolæ in ipsis valvulis conspicuæ. Laminæ foliaceæ quatuor, intra pallii laminas receptæ (branchiæ?). Laminæ triangulares quatuor os cingentes. Cor dorsale. Os et anus oppositi, in utraque corporis extremitate. =CONCHIFERA, Lam.

1. Pallium sacciforme, foramine pedem emittente et in tubos geminos exsertos elongatum. Habitant sub arena aut saxis seu ligno inclusa.—*Les Enfermes*, Cuv.
2. Acephala testacea pallio antice aperto, ostiolis duobus, sæpius in tubos elongatis, instructo, uno in anum altero ad branchias aperiente. Pedes distincti. Fossulæ musculurum testam claudentium in valvulis binæ.—*Cardiacea*, Cuv.
3. Acephala testacea pallii orificiis tribus in parte testæ aut anteriori aut media. Musculus testam claudens unicus.—*Les Benitiers*, Cuv.
4. Acephala testacea, pallio longitudinaliter aperto et orificio proprio ad anum instructo. Pedes distincti. Fossæ musculorum testam claudentium in valvulis binæ.—*Mytillacea*, Cuv.
5. Acephala testacea, pallio aperto, tubo nullo, pede nullo aut brevissimo. Testa utplurimum affixa, sæpius massa byssacea, fissuram aut sinum testæ permeante.—*Ostreacea*, Cuv.

Order III. GASTEROPODA. Mollusca ventre complanato elongato. Caput in plurimis protractum et tentaculatum. Corpus nudum aut testaceum. Organa respirationis seu externa seu interna. Organon respirationi inserviens internum aut simplici foramine seu fissum apertum, aut tubo apertum.

1. CYCLOBRANCHIATA, Cuv. Gasteropoda branchiis foliaceis sub pallio utrinque reconditis. Hermaphrodita. Coitus nullus. Cor ab intestino recto disjunctum.
2. ASPIDOBRANCHIATA=Scutibranches, Cuv. Gasteropoda testa scutiformi, branchiis pectiniformibus. Hermaphrodita. Coitus nullus. Intestinum rectum cor permeans.
3. CTENOBRANCHIATA = Pectinibranches, Cuv.—

Gasteropoda branchiis pectiniformibus, in vesica propria reconditis. Tentacula duo. Sexus distinctus. Os proboscideum. Penis in plurimis exsertus, non retractilis.

A. Testa depressa, spiris brevissimis, ostiolo amplo. Gen.: Sigaretus.

B. Vesica branchialis tubo proprio aperta. Tubus exsertus. Testa cochleata, prope collumellam excisa aut sulco aut canali, tubum excipiente.=*Les Buccinoides*, Cuv.

C. Ctenobranchiata. Vesica branchialis fissura simplici aperta. Testa spiralis, ore in plurimis operculato *Les Trochoides*, Cuv.

4. Cœlopnoa seu Cilopnoa. Gasteropoda vesica pulmonacea aërem respirante.

A. Vesica pulmonacea fissura aperta. Species sexu distinctæ. Cochlea operculo munita. Penis non retractilis exsertus. Tentacula quatuor. Gen.: Cyclostoma.

B. Vesica pulmonacea ostiolo simplici aperta. Species omnes hermaphroditæ, plurimæ cochlea vestitæ. Operculum nullum. Penis retractilis.=*Les Pulmonés*, Cuv.

a. C. aquatilia. Caput tentaculis cylindraceis duobus.

b. C. terrestria. Caput tentaculis filiformibus quatuor.

5. Pomatobranchiata=*Tectibranches*, Cuv. Gasteropoda branchiis lamellosis, aut dorsalibus, aut unilateralibus, pallio plus minusve obtectis sæpiusque testa. Species hermaphroditæ, coëuntes.

6. Hypobranchiata=*Inferobranches*, Cuv. Gasteropoda corpore nudo branchiis lamellosis lateralibus sub margine pallii utrinque insertis.—Species omnes hermaphroditæ, coëuntes, marinæ.

7. Gymnobranchiata = *Nudibranches*, Cuv.—Gasteropoda corpore nudo, branchiis dorsalibus aut lateralibus nudis.—Species omnes marinæ, hermaphroditæ, coëuntes.

Order IV. Pteropoda, Cuv. Mollusca ore membrana alæformi utrinque cincto. Tentacula nulla aut abbreviata.

Order V. Cephalopoda, Cuv. Mollusca. Organa locomotionis (tentacula seu pedes) caput coronantia. Rostrum mandibulis corneis incurvis. Oculi late-

rales magni. Corpus sacciforme, collo coarctato, tubo conico exserto, apice aperto.

A. Corpus testaceum.

a. Testa unilocularis.

b. Testa laminis transversis multilocularis.

B. Corpus nudum=Sepia, Lin.

In Britain Conchology was thoroughly Linnæan; and the very names of Cuvier and Lamarck were scarcely known to its followers when, in 1815, the peace opened up access to the continent. That there were students in the art amongst us, to some numbers, is made certain by the publication of several Introductions, and by the active diligence displayed in the search more especially of indigenous shells. Lister laid the foundation of a native conchology* on which no other could then build; but, to its ultimate completion, Petiver contributed a few species, Pennant something more, and Da Costa also something in a separate volume, published in 1778, of considerable pretensions and some merit.† They found successors in men of like minds and capacity, amongst whom it is sufficient here to specify Mr. Boys, of Sandwich, the first to investigate our minute shells, Dr. Pulteney, Mr. Donovan, Mr. Adams of Pembroke, and Captain Laskey, who carried these researches into Scotland, — researches which were cloaked with the veil of science to hide their real nature, for I do not overstate the truth when I tell you that they were in reality instituted more to gratify an innate taste for collecting things beautiful and rare, than for any wider object. In 1803, Mr. Montagu, however, enriched us with his "Testacea Britannica," which was completed in 1808. In the preface some misgivings of the perfectness of the Linnæan system are feebly hinted; and, in the body of the work, a very few additional genera are defined, with an apology for the bold innovations; but, albeit willing enough to look in this direction, we cannot see in these symptoms the small cloud that was about to usher in the fruitful change. For shortly before the completion of the "Testacea Britannica," there appeared, in the Linnæan Transactions, a descriptive catalogue of the British Testacea by Dr. Maton and the Rev. Thomas Racket,‡—men of note in their day,—and the work was well done in the established fashion, slavishly Linnæan in manner at least, with its definitions and divisions, its trivial and natural characters, a

* Historiæ Animalium Angliæ tres tractatus. *Lond.* 1678.

† Historia naturalis Testaceorum Britanniæ; or, The British Conchology, &c. By Emanuel Mendes da Costa. 4to. *Lond.*, 1778.

‡ Vol. viii. *Lond.*, 1807.

goodly display of synonymes, and — not one word of animal structure, or of the economy of the creatures that builded the models they described. When we were students this catalogue of Maton and Racket's was in high estimation, and we have heard it dictatorially pronounced to be an excellent model, in a sort of pseudo-critical comparison of it with Montagu's ever-during work!

This very slight sketch gives you a true picture of what Conchology was with us in 1815 and for some subsequent years; but a change was at hand, which was effected by the joint labours of Dr. Leach, the Rev. John Fleming, and Mr. John E. Gray.*

Dr. Leach cast aside contemptuously the fetters of the Linnæan school, and, with ardent vigour, he adopted and advocated the French systems, which he sought to improve by working in the same direction, and under the guidance of the same principles. He, however, published little that bore directly on Conchology. He was the first to propose the division of the naked Cephalopods into two families, from the number of their tentacular feet; he first discovered the true structure of the ligament of the Bivalves; and he, discriminating their peculiar features, collected certain species under new genera or families, for he was very nice in detecting differences amid common resemblances, and attached too much importance to slight variations from his fondness for analysis.

On the contrary, his friend Dr. Fleming, a Scotch clergyman, proceeded with the caution which is said to be characteristic of his countrymen. In his interesting article, "Conchology," contributed to the "Edinburgh Encyclopædia," and published in 1815, he has stated many obvious objections to the system of Linnæus; and he has given outlines of those of Bruguiere, Bosc, and Lamarck, which he ventured rather faintly, however, to praise. As he limited himself, in this article, to the description of British shells, he did not indicate his views of the arrangement of the Mollusca in general; and the subjoined outline of his partial method will show you how purely conchological and Linnæan this eminent and sagacious naturalist was at this period:—

* In 1822 the Elements of Conchology, including the Fossil Genera and the Animals, by T. Edward Bowdich, was published at Paris,—a very useful work, but little known in this country, and hence its influence must have been inconsiderable. Yet it would seem that in 1825 Lamarck's system began to have some favour, for an epitome of it was published by Charles Dubois, F.L.S., in that year. The low estate of conchology amongst us is, however, made more evident by this work, for in his translation, Mr. Dubois omits all the characters derived from the animals.

Order I. UNIVALVES.

Division I. Unilocular.

Section I. Astulidia. *Shells destitute of a pillar or columella upon which they are formed.* The "Univalvia absque spira regulari" of Linnæus.

Family 1. Expanded. Genera: Patella, Haliotis, Sigaretus.

,, 2. Tubular. Genera: Dentalium, Cæcum, Serpula.

Family 3. Flask-shaped. Genus: Lagena.

,, 4. Spiral. Genera: Spirorbis, Planorbis.

Section II. Stulidia. *Shells more or less spiral and revolve round a central pillar or columella.* The "Univalvia spira regulari" of Linnæus.

Family 1. Turreted.

Tribe 1. *Canaliculated.* Genera: Buccinum, Murex, Strombus.

,, 2. *Entire.* Genera: Turbo, Odostomia, Lymnæa.

,, 2. Globose. Genera: Helix, Nerita, Trochus.

,, 3. Convoluted. Genera: Cypræa, Voluta, Bulla.

Division II. Multilocular.

Genera:

Nautilus, Orthocera, Spirolina, Miliola.

Order II. BIVALVES.

Division I. Dentated.

Genera:

Mya, Ligula, Solen, Tellina, Pandora, Corbula, Cardium, Cyclas, Mactra, Lutraria, Donax, Venus, Isocardia, Terebratula, Nucula, Arca, Pectunculus.

Division II. Toothless.

Section I. Inequivalve. Genera: Pecten, Ostrea, Anomia.

Section II. Equivalve. Genera: Mytilus, Pinna.

Order III. MULTIVALVES.

Division I. Dentated.

Genera:

Pholas, Teredo.

Division II. Toothless.

Section I. Operculated. Genera: Balanus, Coronula.
Section II. Pedunculated. Genus, Lepas.
Section III. Imbricated. Genus: Chiton.

But in 1820, when Dr. Fleming published the article "Mollusca" in the same Encylopædia, he had shaken off the Linnæan yoke, and had become a follower of Cuvier, without treading exactly in his steps, as if resolute not to wear the livery of his master, while, at the same time, he derived from him his sustenance and position. What led Dr. Fleming truant and aside, as I deem his deviations from Cuvier to have been, was the importance he attached to the binary method of analysing the great classes of animals into their less and lesser divisions,—a method which may often be called into useful aid when the search after a genus by artificial devices is alone the object, but which adhered to in any system that pretends to arrange animals according to their affinities, as indicated by their general identity of structure,—and that was Cuvier's object,—will sever far asunder kindred races.* The truth of this remark is made obvious by an examination of Dr. Fleming's method, which we extract, as re-printed in his very valuable work, the "Philosophy of Zoology," ann. 1822.

* Dr. Fleming, in the preface to his "Philosophy of Zoology," has vindicated his predilection for this binary method, in some remarks which are worth quoting. "There is now much declamation about the worthlessness of Artificial Systems, and the excellence of Natural Methods. But this excellence is more apparent than real. Many of those natural groups which are so much praised are ill defined, and it is even acknowledged by their admirers that precise limits cannot be assigned to them. Hence it frequently happens that the definition of the group is applicable to a few genera only, which are considered as its type, and does not embrace other genera which are regarded as belonging to it, but beginning to assume the characters of some of the other neighbouring groups. There is here the use of a method where there is no precision, and a boasting that the plan of nature is followed, when that plan is confessedly incomprehensible. Indeed, it often happens that the admired natural method of one zoologist differs from the censured artificial method of another, merely in the circumstance that different systems of organs have been made choice of as the basis of the respective classifications. Unless zoologists, in the formation of their primary groups, endeavour to determine those characters which all the members possess in common, admitting only such marks into the definition, and practise the same method with all the subordinate divisions, the progress of the science will be unsteady, the student will be startled at its contradictions, and the revolutions in nomenclature become as frequent as the cultivators of the science are numerous."

INVERTEBRATA.—GANGLIATA.

MOLLUSCA.

Division I. Mollusca Cephala.

Section I. Natantia.

Class I. Cephalopoda.

Order I. Nautiliadæ.—Spirula, Nautilus, and the multilocular Testacea.

Order II. Sepiadæ. (1.) Head surrounded with eight arms and two feet. Sepia, Loligo. (2.) Head surrounded with eight arms, without feet. Octopus, Eledona, Ocythoe.

Class II. Pteropoda.

I. With a shell. Limacina, Hyalea.

II. Destitute of a shell. A. Fins double. Pneumodermon, Clio, Cleodora. B. Fin single. Cymbulia.

Section II. Gasteropoda.

Class I. Pulmonifera.

Order I. Terrestrial.

Subdivision I. Cloak and foot parallel. Arion, Limax, Parmacella, Testacella, Veronicellus, Onchidium.

Subdivision II. Cloak and foot not parallel.

Tribe I. Foot with a lid. Cyclostoma.

Tribe II. Foot destitute of a lid. Helix, Bulimus, Pupadæ, Vitrina, Succinea, Achatina.

Order II. Aquatic.

Subdivision I. Body protected by a shell.

Tribe I. Shell spirally twisted. A. Shells turreted. Lymneus, Physa, Aplexa. B. Shells depressed. Planorbis, Segmentina.

Tribe II. Shell conical. Ancylus.

Subdivision II. Body destitute of the protection of a shell. Peronia.

Class II. Branchifera.

Order I. Branchiæ external.

Tribe I. Branchiæ exposed.

A. Branchiæ issuing from the cloak dorsally.

1. Body exposed and destitute of a shell. *a.* Doris, Polycera. *b.* Tergipes, Tritonia, Montagua, Eolida, Scyllæa, Glaucus, Thethys.
2. Body concealed in a spiral shell. Valvata.

B. Branchiæ issuing laterally from between the cloak and foot.

1. Body with a shell. *Cyclobranchia.* Patella, Chiton, Chitonellus.
2. Body naked. *Inferobranchia.* Phyllidia, Diphylidia.

Tribe II. Branchiæ simple, and concealed when at rest under a lid. *Tectibranchia.*

A. Head furnished with tentacula.

1. Tentacula four in number. *a.* Aplysia, Notarchus. *b.* Dolabella.
2. Tentacula, two in number. Pleurobranchus.

B. Head destitute of tentacula. Bulla, Doridium.

Order II. Branchiæ internal.

Subdivision I. Heart entire and detached from the rectum.

Tribe I. Shell external.

A. Aperture of the shell entire.

1. Aperture of the shell closed by a lid. Turbonidæ, Neritidæ, Trochusidæ.
2. Aperture of the shell exposed. Ianthina, Velutina.

B. Anterior margin of the aperture of the shell canaliculated.

1. Shell convoluted. Cypreadæ, Ovuladæ, Volutadæ.
2. Shell turreted. Buccinidæ, Muricidæ, Cerithiadæ, Strombusidæ.

Tribe II. Shell internal. Sigaretus.

Subdivision II. Heart traversed by the rectum.

Tribe I. Shell ear-shaped. Haliotidæ.—Haliotis, Padola, Stomatia.

Tribe II. Shell conical. Crepiduladæ, Capulusidæ, Fissurelladæ.

Division II. Mollusca Acephala.

Section I. Acephala Conchifera.

Order I. Brachiopoda.

Subdivision I. Shell supported on a fleshy peduncle. Lingula, Terebratula.

Subdivision II. Shell sessile. Criopus.

Order II. Bivalvia.

Subdivision I. Cloak open.

Tribe I. Valves closed by one adductor muscle. Pectenidæ, Ostreadæ.

Tribe II. Shell closed by two adductor muscles. Avicularia, Meleagrina, Pinna, Arcadæ.

Subdivision II. Cloak more or less closed, forming siphons.

Tribe I. One siphon. Mytilusidæ, Uniodæ, Cardita, Venericardia, and Crassatella.

Tribe II. Cloak closed posteriorly and anteriorly, forming three apertures. Tridacna and Hippopus.

Tribe III. Anterior opening large. Chama, Cardium, Donax, Tellina, Venus, Mactra.

Tribe IV. Anterior opening small. Mya, Solen, Pholas, Teredo.

Section II. ACEPHALA TUNICATA.

Subdivision I. Interior tunic detached from the external one, and united only at the two orifices.

Tribe I. Body permanently fixed to other bodies.

A. Simple Animals.

1. Apertures furnished with four rays. Boltenia, Cynthia, Cæsira, Styela, Pandocia.
2. Apertures with indistinct rays of more than four. Clavelina, Pirena, Ciona, Phallusia.

B. Compound animals.

1. Branchial orifice radiated.

a. Branchial and anal orifices with six rays. Diazona, Polyzona, Sigillina.

b. Branchial orifice only furnished with six rays. Synoicum, Sydneum, Polyclinum, Aplidium, Didemnum.

2. Branchial orifice simple. Botryllus. Euclæium.

Tribe II. Body free and moving about in the water. Pyrosoma.

Subdivision II. Interior tunic adhering throughout to the external one.

Salpa.

I have next to lay before you the "Natural Arrangement of Mollusca according to their internal Structure," proposed by John Edward Gray. (March, 1821.)*

Sub-kingdom—MOLLUSCA, Cuv.

Animal without any bony skeleton; muscles attached to the skin; skin soft, not articulated nor annulated; nervous system irregular.

* London Medical Repository, xv. 229—239.

Class I. ANTLIO-BRACHIOPHORA=Cephalopoda, Cuv.

Head very distinct, base with a cartilaginous ring; eyes 2, lateral, very large; arms 8, 10, round the mouth, armed with suckers. (Antliæ.) Branchia arborescent, 2-lobed, close on each side, enclosed in the large sack-like mantle, open above in front. Protectors, or shells, more or less developed.

Order I. ANOSTEOPHORA. Protectors 2; arms 8, equal; body finless. *Gen.* Octopoda.

Order II. SEPIÆPHORA. Protectors horny or cretaceous; arms 10, 2 longer; body 2-finned below. *Gen.* Sepiola, Sepia.

Order III. NAUTILOPHORA. Protectors or shells many-chambered, straight or discoidal; arms 10, 2 longer; body 2-finned below. *Gen.* Orthocera, Spirula, Cristellaria, Spherula, Rotaclea, Nautilus, Ammonita.

Class II. GASTEROPODOPHORA=Gasteropoda, Cuv.

Head distinct; organs of vision 2, small; foot flat, on the ventral disk, formed for walking; branchia more or less developed; mantle conical, sack-like; protectors none, or coriaceous, or shelly; shell univalve, or many placed in a series.

Sub-class I. PNEUMONOBRANCHIA. Branchia not developed; breathing free air.

Order I. ADELOPNEUMONA. Branchia not developed; pulmonary vessels spread over the branchial cavity; branchial cavity closed by a valve: half hermaphrodite: operculum none: shell more or less developed, not symmetrical, spiral; aperture spread. Terrestrial or aquatic, breathing free air.

(*a.*) *Tentacula retractile, terrestrial.* *Gen.* Limax or Limacideæ, Onchidium, Plectophorus, Testacella, Vitrina, Helix, Achatina, Clauselia.

(*b.*) *Tentacula contractile, cylindrical; amphibious.* Auricula, Carychium, Phytia.

(*c.*) *Tentacula contractile, compressed; aquatic.* Lymnæa, Planorbis, Ancyllus.

Order II. PHANEROPNEUMANA. Branchia not developed; pulmonary vessels spread over the branchial cavity; branchial cavity open: mantle free in front: unisexual: operculum distinct: shell not symmetrical, spiral; aperture small. Terrestrial; breathing free air. *Gen.* Cyclostoma, Helicina.

Subclass II. CRYPTOBRANCHIA. Branchia under the mantle. Breathing water.

Order III. CTENOBRANCHIA. Branchia pectinated in a longitudinal series on the inside of the mantle, on the columella side: mantle free in front, mostly extended into a siphon: unisexual: operculum mostly distinct: adductor muscle attached to the columella of the shell: shell not symmetrical, spiral, or involute; aperture contracted. Marine, rarely fresh water. Breathing water.

(*a.*) *Operculum cartilaginous bullated: floating shell downwards. Gen.* Ianthina.

(*b.*) *Operculum spiral articulated to the columella.* Neritina, Navicellus.

(*c.*) *Operculum spiral, free.* Nerita. Melas. Operculum ovate, nucleus basillary, spire few-whorled.—Turbo. Operculum orbicular, nucleus subcentral, spire few-whorled.—Trochus, Valvata, Cerithium. Operculum orbicular, nucleus central, spire many-whorled.

(*d.*) *Operculum annular; nucleus subcentral, regular.*—Paludina. (Vivipara: Operculum horny, nucleus lateral. Ampularia: Operculum shelly, nucleus lateral. Bithinia: Operculum shelly, nucleus central.)

(*e.*) *Operculum annular; nucleus apicular, irregular.*—Murex, Voluta, Strombus, Conus.

(*f.*) *Operculum none; shell subinternal.*—Cypræa, Volva.

Order IV. TRACHELOBRANCHIA. Branchia pectinate, in a transverse row round the inside of the mantle over the neck: mantle free in front: unisexual: operculum none: adductor muscle attached to the columella, submarginal: shell not symmetrical; aperture effused. Marine. Breathing water.

(*a.*) *Adductor muscle near the columella: shell ear-shaped; apex spiral.*—Sigaretus, Cryptostoma.

(*b.*) *Adductor muscle submarginal, horse-shoe shaped: shell conical; apex incurved.*—Velutina, Capulus, Stomatia.

(*c.*) *Adductor muscle marginal: shell depressed; aperture with a transverse internal lip.*—Crepidula.

(*d.*) *Adductor muscle subcentral: shell conical; aperture with an internal lip.*—Calyptræa, Mitrula.

Order V. MONOPLEUROBRANCHIA. Branchia lamellar or arborescent on the right side, between the mantle and the foot: anus behind, orifice of generation

before the branchia: half hermaphrodite: operculum none: protectors or shell not symmetrical, flat or slightly convolute, aperture very large, entire. Marine, breathing water.—*Gen.* Umbrella, Pleurobranchia, Laminaria.

Order VI. NOTOBRANCHIA. Branchia arborescent, on the right side of the back, under a fold of the mantle: anus and orifice of generation on the right side: half hermaphrodite: operculum none: protectors or shells not symmetrical, more or less convolute; aperture effused, entire. Marine, breathing water. *Gen.* Aplysia, Bulla.

Order VII. SCHISMATOBRANCHIA. Branchia arborescent, two-lobed on the columella side: mantle with a longitudinal slit over the branchia: rectum passing through the two-ventricled heart, and between the lobes of the branchia: hermaphrodite: operculum none: adductor muscle nearly central: shell not symmetrical; apex spiral; columella side perforated above. Marine, breathing water.—*Gen.* Haliotis.

Order VIII. DICRANOBRANCHIA. Branchia arborescent, two-lobed, one lobe on each side: mantle slit or perforated in front over the branchia: rectum passing through the two-ventricled heart, and between the lobes of the branchia: hermaphrodite: operculum none: adductor muscle circular, submarginal: shell symmetrical, conical, perforated or slit. Marine, breathing water. *Gen.* Fissurella, Scutus, Diodora, Imarginula.

Order IX. CYCLOBRANCHIA. Branchia laminar, round the under suface of the mantle just above the foot: anus and aperture of generation on the right side: tentacula 2: hermaphrodite: operculum none: adductor muscle circular, submarginal: shell symmetrical, conical, of one piece, imperforated. Marine, breathing water. *Gen.* Patella.

Order X. POLYPLACOPHORA. Branchia laminar, round the under surface of the mantle just above the foot: mantle-edge coriaceous: anus terminal: tentacula none: hermaphrodite: operculum none: protectors symmetrical, composed of arched shelly plates, implanted in the middle of the back. Marine, breathing water.

(*a.*) *Plates placed on the back of the mantle.*—Gymnoplax or Gymnoplacidæ, Acanthochitona, Chiton, Lepidochitona.

(*b.*) *Plates sunk in the back of the mantle.*—Crytoplax.

Order XI. DIPLEUROBRANCHIA. Branchia laminar, round the under surface of the mantle, just above the foot: mantle coriaceous, scattered with retractile tubercles: anus dorsal, subterminal: tentacula 4: organs of generation on the right side: half hermaphrodite: protectors none. Marine, breathing water. *Gen.* Phyllidia.

Subclass III. GYMNOBRANCHIA. Branchia on the outside of the mantle. Marine, breathing water.

Order XII. PYGOBRANCHIA. Branchia arborescent, external, on the back of the mantle round the anus: mantle coriaceous, scattered with retractile tubercles: anus dorsal, subterminal: tentacula 4: organs of generation on the right side: half hermaphrodite: protectors none. Marine, breathing water. *Gen.* Doris.

Order XIII. POLYBRANCHIA. Branchia arborescent or vermicular, external, on the sides or on the back of the mantle: mantle coriaceous: anus and organs of generation on the right side: half hermaphrodite: protectors none. Marine, breathing water. *Gen.* Tritonia, Scyllea, Eolis, Tergipes, Tethys, Glaucus.

Class III. GASTEROPTEROPHORA.

Head distinct; organs of vision 2: body elongate, free (floating horizontally belly upwards): foot on the ventral disk: arms or fins round the head none: fin 1, towards the hinder part of the ventral disk: branchia pectinated, inside the conical mantle: anus lateral: shell symmetrical, conical, involute, very thin; aperture rather angular: opposite to the ventral fin. Marine, breathing water. *Gen.* Pterotrachea. (Carinaria, Argonauta.)

Class IV. STOMATOPTEROPHORA=Pteropoda, Cuv.

Head more or less distinct: body elongate, free (floating): foot none distinct: mantle mostly double, extended in front into the form of two membranaceous fins: hermaphrodite: protectors none, or very thin. Marine, breathing water.

Order I. PTERABRANCHIA. Head distinct: branchia external on the fins: mantle sack-like: shell none or univalve.

(*a.*) Shell spiral. Limacina.

(*b.*) Protector or shell straight. Cleodora, Cymbula.

(*c*.) Protector or shell none. Clio, Pneumoderma: a distinct order?

Order II. DACTYLIOBRANCHIA. Head none distinct: mantle two-leaved: branchia lamellar, in a ring on the lower side of the body, between the leaves of the mantle, opposite to the lateral slits: shell sub-two-valved: hind part soldered, perforated, sides slit, front open. *Gen.* Hyalea.

Class V. SACCOPHORA.=Tunicata, Lamk.

Head, eyes, foot, arms or fins, none distinct: mantle soft, sac-like, double, one enclosing the other; with two apertures, one for respiration, the other for digestion: branchia lamellar, covering the whole or part of the parietes of the branchial cavity: mouth at the bottom of the branchial cavity, furnished with labial tentacula: hermaphrodite: protectors none. Marine, breathing water.

Order I. HOLOBRANCHIA. Fixed to other bodies. Mantle and tunic separate, except at the apertures: branchial lamellæ large, uneven, contiguous at the sides, covering the parietes of the branchial cavity: branchial cavity with only one aperture; aperture surrounded on the inside with a circle of filaments, not opposite to, nor communicating directly with, the anal opening.

(*a*.) Simple. *Gen.* Boltenia, Phallusia.

(*b*.) Compound. Distoma, Synoicum, Eucœlium.

Order II. TONOBRANCHIA. Free, floating about. Shell and tunic separate from the mantle, except at the apertures: branchial lamellæ large, uneven, not contiguous at the sides, nearly covering the parietes of the branchial cavity: branchial and anal opening diametrically opposite: branchial cavity open at both ends; anterior opening furnished with a denticulated ring: fringes none. (Compound.) *Gen.* Pyrosoma.

Order III. DIPHYLLOBRANCHIA. Free, floating about; shell or tunic adhering to the mantle in all parts: branchial lamellæ two, narrow, united: branchial orifice with a valve. *Gen.* Salpa.

Class VI. CONCHOPHORA.=Acephala testacea, Cuv.

Head none distinct: foot one, compressed: mantle 2-leaved, one on each side of the foot, more or less soldered together: branchial lamellæ 2 on each side, placed between the foot and the mantle leaves: mouth just before the foot,

with 2 lips on each side: rectum traversing the heart: adductor muscles, one or more, for closing the shell: shell 2-valved; valves attached to each other by a hinge on one side, the other side and the two ends free. Marine, rarely fresh water; breathing water.

Order I. CLADOPODA. Animal — adductor muscle posterior: mantle, sides soldered, front open: foot thick, clubbed, passing out in front: shell gaping in front, opened by an external adductor muscle, generally protected by accessory pieces, and closed by one adductor muscle: elastic ligament none. *Gen.* Pholas, Teredo, Aspergillum.

Order II. PACHYPEDA. Animal — adductor muscles 2, distinct, anterior and posterior: mantle side soldered, front open: foot thick, passing out in front: shell regular, mostly inequivalved, gaping at the ends: elastic ligament internal, in a tooth. Mya, Corbula.

Order III. LEPTOPODA. Animal — adductor muscles 2, distinct, anterior and posterior: mantle side open: foot small, compressed: shell regular, generally equivalved, gaping, more or less, at the ends: elastic ligament internal, in a tooth. Mactra, Nucula.

Order IV. PHYLLOPODA. Animal — adductor muscles 2, distinct, anterior and posterior: mantle side open: foot small, lamellar: shell regular, equivalve: elastic ligament marginal, linear, external.

(*a.*) Solen, Psammobia, Tellina.

(*b.*) Cyclas, Venus, Cardium, Tridacna, Chama, Pectunculus, Trigonia, Unio.

Order V. POGONOPODA. Animal — adductor muscles 2, anterior and posterior: mantle side free: foot very small, with a bundle of byssus in front: byssus ending in suckers: shell equivalve: elastic ligament marginal, linear. Arca, Mytilus, Avicula.

Order VI. MICROPODA. Animal — adductor muscle one (or two or three close together), nearly central: mantle side free: foot very small: shell mostly inequivalve: elastic ligament internal, short, in a hollow; not marginal. Pecten, Ostrea, Anomia.

Remarks.—"So little is known of the animals of this class individually, that it may, perhaps, be better to arrange them by the shell, elastic ligament, and muscular impressions only; as in the following manner:—

"*a.* Elastic ligament none: adductor muscle external:

muscular impressions solitary behind. MYOSTROPHA.—*Gen.* Pholas, Teredo, Aspergillum.

" *b.* Elastic ligament internal: muscular impressions two, anterior and posterior. DIAPEDASTROPHIA. — *Gen.* Mya, Corbula, Mactra, Nucula.

" *c.* Elastic ligament external, marginal; muscular impressions mostly two, anterior and posterior. — *Gen.* Solen, Psammobia, Tellina, Cyclas, Venus, Cardium, Tridacna, Chama, Pectunculus, Trigonia, Unio, Arca, Mytilus, Gastrochæna, Avicula.

" *d.* Elastic ligament internal, not marginal: muscular impressions one, subcentral.—*Gen.* Pecten, Ostrea, Anomia."

Class VII. SPIROBRACHIOPHORA.=Brachiopoda, Cuv.

Head none distinct: foot none for walking: arms two, spiral, fringed, between the lobes of the mantle: mouth between the base of the arms; mantle two-leaved: branchia lamellar, pectinated on the inner surface of the lobes of the mantle: adductor muscles three or four for closing the shells: shell two-valved, hinge at one end, the other end and two sides open; fixed to other bodies. Marine, breathing water.

(*a.*) Shell unequivalved; lower valve flat, affixed beneath: hinge none.—Criopus, Crania.

(*b.*) Shell unequivalved, peduncle tendinous coming through a perforation or nick in the larger valve: hinge toothed.—Terebratula.

(*c.*) Shell nearly equivalve, with a long tendinous peduncle coming from between the apices of the valves: hinge toothless.—Ligula.

This arrangement has much of the manner of a student's essay, with all its elaborate care and its harsh phraseology; but it most undoubtedly proves Mr. Gray's knowledge of what was doing for Conchology abroad, and his mastery of the works published to advance it; while, at the same time, it contains evidence enough of much personal observation. Buried at its birth in the pages of a rather obscure medical journal, it remained neglected at home, and unknown on the Continent, until reprinted, three years afterwards, in the "Bulletin des Sciences naturelles" of the Baron de Férussac. Its merits as a whole are doubtful, and not considerable enough to have gained for it any followers; but it presents a few novel views which may have had some influence over subsequent classifications. The method in the main is borrowed from Cuvier; but Blainville has been

evidently the author's model. It has its seven classes corresponding pretty exactly to those founded by the author of the Règne Animal; but it has one class more, made at the expense of the Pteropods; and as all the classes are presumed to be of equal value, Mr. Gray misses the natural division of them into two series from the existence or non-existence of a head, as Cuvier had likewise done.

The first class embraces the Cephalopods, and the subordinate sections correspond nearly with those already proposed. The Pulmonata introduce the second class,—a fault to be remarked also in Cuvier's method, and which has arisen from not attaching sufficient importance to the sexual peculiarities of the race. The other Gasteropods are ranked strictly by the form and nature of the operculum, which has led to certain approximations startling to those conchologists who had settled down in the faith that it was necessary to divide the Gasteropods only from the entire, or effuse, or canaliculated state of the aperture of their shells.

The third class is instituted to embrace two genera,—the Argonauta and Carinaria,—whose position had puzzled every systematist. Mr. Gray misinterpreted the puzzle also, misled by the general resemblance there is between the shells of the two genera, which are now well-known to belong to different categories. The fourth class is related to the preceding one, and includes the Pteropods of Cuvier. There has always been a difficulty in deciding by what series of genera the cephalous graduate into and mingle with the acephalous Mollusca. Lamarck decided that the Pteropods were the media, emerging from a lower and arrested in their exodus to a higher life; and M. de Férussac judged the passage to be through the class of Cephalopods. M. de Blainville, throwing aside idle speculation, demonstrated, by anatomical research, that the transition is made by means of a small number of genera related to the Limpets, viz., the Hipponyx and Pileopsis. Mr. Gray, proceeding on unassigned views or, perhaps, empirically, placed the naked Acephales immediately after the Pteropods, and made them lead the way to the true Bivalves,—reversing that mode of development which Lamarck had, with equal gratuity, assigned them.

The sixth class is nearly coequal with the Conchifera of Lamarck. Mr. Gray divides it into six orders from the form of the foot, availing himself of the discoveries of Poli. M. Goldfuss had also attempted a classification of the lamellibranchiate Mollusca on the same characters; and although, like Mr. Gray, he had thence been led to some happy alliances of groups or of genera, there were other groups, on the

contrary, which were forced into combinations as artificial as by any the most arbitrary methods. What, for example, but adherence to an arbitrary rule could bring the Mactra and the Nucula into close affinity, and fix in the same order the Pectunculus and the Chama with the Solenes, the Tellinæ, and the Venusidæ; and the Arcæ with the mussels and the Aviculæ? It is time, says Deshayes, to renounce these artificial arrangements founded on a single character, arbitrarily assumed and made to dominate over all others. To be natural, a classification ought to take into consideration the whole essentials of the organism in the definition and circumscription of the principal groups. It is by acting on this principle that the best zoologists have arrived nighest to the purposed end of their ingenious labours.

A review of these various systems will have satisfied you, I think, that none of them are superior, or even equal, to Cuvier's,—the source and parent of them all. The first outline of Cuvier's was published on the 10th of May, 1795; the last finish was given to it in March, 1830, and the strong impress of it on the progress of Conchology can never be erased. He has lifted the subject above raillery and ridicule, and placed, in its due rank, a large class of animals, than which none other more deservedly claim the attentions of the naturalist, the physiologist, and the geologist.

Note to page 532.

To understand the original points in this and subsequent classifications of the Tunicata, it is necessary to keep in view that of Jules-César Savigny, founded on the most delicate and elaborate dissections. Hence I shall here give a synopsis of it, with a few preliminary remarks.

Dr. John Albert Schlosser was the first to describe a beautiful and common production on our shores, which Linnæus named Alcyonium schlosseri. It is a firm gelatinous crust growing on sea-weeds and, less frequently, on stones; the surface marked with numerous small pear-shaped bodies arranged round a central dot, and thus simulating a star as this is figured in geographical maps. Schlosser believed that all these bodies which entered into the composition of each star were intimately united at their smaller end, and constituted a true animal "much more beautiful than any polype, but quite of a different structure." In each pear-shaped body he detected, near the outer extremity, a small circular hole, which contracts and opens frequently; and in their common centre another "opening of a circular, oval, or oblong figure, forming a kind of rising rim like a cup, which, when the animal is alive and at rest, contracts and expands itself to many different degrees, with great alertness and velocity, though sometimes it remains a great while expanded or contracted." At neither of the apertures could he perceive any tentacula, "but by looking into them very narrowly, he saw something like very tender little fibres moving at the bottom of their insides." He believed the smaller aperture to be the mouth. Phil. Trans. an. 1755, abridg. x. 670.

Ellis also examined this production. He found that all the interstices

between the stars were filled with eggs of different sizes, "each adhering by one end to a very fine capillary filament. The smallest eggs are globular, and as they advance in size, they change to an oval figure; whence they assume the shape of one of the radii of the stars." Ellis ascertained "that each radius is a distinct animal by itself." Lib. cit. x. 671.—In his Essay on Corallines, Ellis described another species, but his account of its structure is very inaccurate.

Pallas and Linnæus referred these species to the genus Alcyonium, under a false view, evidently, of their organisation. Gærtner confirmed Ellis's opinion that each ray of the star was a separate animal; and, after a long interval, MM. Peron and Lesueur and M. Desmarest described one or more other species, indicating their structure to be of higher complexity than other polypes, without, however, attempting to give them a proper position or arrangement in the Animal Kingdom. For this great step in classification we are entirely indebted to M. Savigny, who published his "Mémoires sur les Animaux sans Vertèbres" in 1816.

His systematic table of the Tunicata is as follows:—
Animaux invertébrés non articulés.
Mollusques hermaphrodites et acéphales.

Class—ASCIDIÆ.

Shell soft, formed by an exterior distinctly organised envelope, furnished with two apertures, a branchial and an anal one. *Cloak* forming an interior tunic, also furnished with two apertures corresponding with those of the shell and adherent to them. *Branchiæ* occupying wholly or in part the surface of a membranous cavity attached to the inner surface of the cloak. *Mouth* without labial laminæ, and situated at the bottom of the respiratory cavity between the two branchiæ.

Order I. Ascidiæ Tethydes.

Cloak adhering to the envelope or *shell* only by the two apertures. *Branchiæ* equal, large, forming the two side-walls of the respiratory cavity. *Branchial orifice* furnished interiorly with a membranous and denticulated ring, or with a circle of filaments.

1. Family—Tethyæ.

Body fixed. *Apertures* not opposite nor communicating by the cavity of the branchiæ. *Branchial cavity* open at the superior extremity only, and its aperture furnished with tentacular filaments. *Branchiæ* united or coalescent on one side.

I. Simple Tethyes.

1. Section. *Apertures with four rays.*
   1. Boltenia. Body pedunculated.
   2. Cynthia. Body sessile.
2. Section. *Apertures with more than four rays, or without distinct rays.*
   3. Phallusia. Body sessile.
   4. Clavelina. Body pedunculated.

II. Compound Tethyes.

3. Section. *Both apertures with six regular rays.*
   5. Diazona. Body sessile, orbicular; a single system.
   6. Distoma. Body sessile, multiform; systems several.
   7. Sigillina. Body pedunculated, conical, vertical; a single system.

4. Section. *Branchial aperture only with six regular rays.*

8. Synoicum. Body pedunculated, cylindrical, vertical; a single system.

9. Aplidium. Body sessile, multiform; systems without central cavities.

10. Polyclinum. Body sessile, multiform; systems with central cavities.

11. Didemnum. Body sessile, fungous, crustaceous; systems without central cavities.

5. Section. *Apertures without rays.*

12. Eucœlium. Body crustaceous; systems without central cavities.

13. Botryllus. Body crustaceous; systems with central cavities.

2. Family—Luciæ.

Body floating. *Apertures* exactly opposite, and communicating by the cavity of the branchiæ. *Branchial cavity* open at both ends, the superior aperture without tentacular filaments, but margined with a denticulated ring. *Branchiæ* disjunct.

I. Simple Luciæ.

II. Compound Luciæ.

14. Pyrosoma. Body in form of a tube closed at one extremity; a single system.

Order II. Ascidiæ Thalides.

Cloak adherent everywhere to the envelop. *Branchiæ* unequal, narrow, consisting of two leaflets attached to the anterior wall, and to the posterior wall of the respiratory cavity. *Branchial aperture* furnished with a valve.

Obs. Savigny did not classify this Order.

LETTER XXVIII.

RECENT IMPROVEMENTS IN THE CLASSIFICATION OF THE MOLLUSCA.

THE system of Cuvier prevailed over the naturalist world, and the happy influence was immediately felt in the higher aims of its followers. Conchology was now understood to be the study of a series of beings which occupied a large space in the eye and plan of Him who created all things, and pronounced them very good. The structure He had given the Mollusca—the functions with which He had endowed them—the relations in which He had placed them towards each other, and to the animal kingdom in general,—and their use and office in the world's economy, were worthy subjects of study to the only intelligence that walked visible amidst this scene of life; created in part for the exercise and improvement of his intellect; and wherein he might, perhaps, discover something of the wisdom and design that planned and coordinated the whole. And so it was seen in the higher talent which occupied the field; than which no other, in natural science, has of late been more cultivated and made more productive of good results to the physiology of life, and to the unveiling of the physical transitions of the globe itself.

The discoveries in every direction which resulted, proved also the soundness of the principles on which Cuvier had proceeded; for it has not been found necessary to alter, in any essential manner, the main sections of his system. These were marshalled in a linear series, and in a descending scale, commencing with the most complexly organized species, and ending with those which were least so.* Lamarck, you may

* As I have previously mentioned, Cuvier was, however, careless of the finical niceties affected by others in their orderly localisation of families, well aware of the impossibility of arranging these in a book according to their affinities in nature. M. Emile Blanchard has well said:—"Tout en ayant l'intention de ne pas négliger absolument l'ordre des rapports naturels dans la description des espèces, je dois le dire, j'attache peu d'importance ici à mettre un genre, une famille même, après ou avant l'autre. Dans le classement des représentants d'un ordre quelconque du règne animal, on ne parvient jamais à ranger les genres et les espèces sur une seule ligne sans rompre les affinités les plus évidentes."—Ann. des Sc. Nat. xi. (1849), 74.

remember, proceeding in the contrary direction, considered the Tunicata to be a very distant tribe, from which the Mollusca could trace back only a doubtful descent; and Blainville made of the Tunicata and one or two other small tribes, a sort of border clans, with which he tenanted a space, otherwise waste, that lay between the Mollusca and the worms. Mr. Macleay's decision as to the rightful position of the orders of the Mollusca, and their catenation, was more ingenious; and in accordance with his general theory, that the series of organic creations form, in their progress, a series of circles, "rolling wheel within wheel, *ad infinitum*." Every circle was a separate class, with its members forming an intimately associated community, yet intimately connected with all the adjacent and even the furthest remote circles, either by ties of organic affinity or of analogy; the ties of affinity proving the immediate connection of the circles and their proper position in the one that embraced the whole; the analogy declaring itself in certain common peculiarities of form and habits which proved how the corresponding groups of separate and even distant circles, were made to symbolise each other. Every circle, moreover, was presumed to be formed of five other circles, each of which was resolvable into five lesser ones, and still even then revolving with a narrower and narrower range as they successively descended to embrace in the circling vortex, the lower and the lowest entities of creation. Thus the animal kingdom was supposed to form a circle that included five great circles, one containing the Acrita or Polypes, and infusory animalcules; the second the radiated; the third the annulose; the fourth the vertebrated; and the fifth the molluscous animals, which, in their most degraded forms, return to and merge into the circles of Acrita. The circle of the Mollusca should, of course, have five classes; but Mr. Macleay's attention not having been particularly directed to this tribe, he could only determine certainly the Acephala and the Pteropoda as occupants of it, and the Brachiopoda doubtfully; while the Cephalopoda and the Tunicata were deemed to be osculant groups, the former allying the Mollusca with the Vertebrata, and the latter making a similar alliance with the Acrita.*

Mr. Swainson, an able and zealous disciple of Macleay's, first attempted the application of this theory, but in a modified form, to the classification of the Mollusca in 1835,† and more fully in 1840.‡ Of the groups which constitute every

* Kirby and Spence's Introd. to Entomology, iii. 12; and iv. 359.
† Elements of Modern Conchology. Lond. 1835. Duod.
‡ Malacology; or, Shells and Shell-fish. Lond. 1840. Duod.

circle, Mr. Swainson considered one to be typical, one sub-typical, and one to be aberrant,—the latter carrying with it two satellitious circles, and wandering away from the perfect character of that to which their organization as a whole proved them to belong. The class Mollusca, then, must, theoretically, have three coequal and two lesser circles, all of an ordinal rank. In 1835, Mr. Swainson said that these were the Gasteropoda, the Acephala, the Nudibranchia, the Pteropoda, and the Cephalopoda; but in 1840, his views were greatly altered. He then says,—"The great natural divisions of the testaceous Mollusca appear to us to be these: —The *first*, or pre-eminently typical, are unquestionably the GASTEROPODA, or spiral univalves, whether we consider the comparative perfection of their internal or their external structure. The *second*, or sub-typical class, is composed of the DITHYRA of Aristotle, or the bivalves, whose structure is less perfect, but which are in like manner protected by a regularly formed, and often richly coloured, bivalve shell. The *third*, or aberrant group, as usual, comprehends three:— 1. The NUDIBRANCHIA of M. Cuvier, or the naked Gasteropoda; 2. The PARENCHYMATA, or intestinal *Testacea*; and 3. The CEPHALOPODA, or cuttlefish." The following diagram may illustrate the circular connection of these orders:—

That these orders form a circular group is not to be proved unless we admit the host of extinct races into the category; and unless we even grant that of some orders, as of the Nudibranchia, there have been many which have not only disappeared from amongst the living, but have not "left even a wreck behind" of their ancient existence.* We must also admit as certain, that Nature begins her creations "from a small rudimentary group,—a point,

* I have never been able to understand why extinct species of a past creation should be admitted into the circular or quinary theory of the existing creation, for it seems natural to believe that, as every successive creation was called into existence, the Creator would make that complete in itself, and without reference to forms that he had willed to annihilate, or predetermined to live at a long distant era. For example, I believe that the zoology of the Old Red Sandstone was a perfect system in itself; just as I believe the existing creation to be so. To permit gaps or empty spaces where the old and now extinct circles were occupants seems to me a defect; but we know that all is perfect and very good.

so to speak, in existence,"—wherein are contained animals that have only a faint trace of affinity to those which, standing at the head, exhibit the typical structure; they possess merely the rudiments "of the perfection to which they gradually, but ultimately lead; and their structure is often so exceedingly simple, that in such as may be termed the germ, even those rudiments are scarcely perceptible. One such, or at most two, are all we can expect to find."—This sentence is intended to allure us to follow the author in his search for the primary races of the Mollusca amongst the intestinal worms; and he finds them there under the guise of slug-like parasites, and of other slug-like worms (Planariæ), that have their habitations in ponds and in the moist earth. "The *Parenchymata*, or parasitic *Mollusca*, may be considered the first indistinct and incipient development of the *Testacea*,—the point from which Nature diverges towards the phytophagous Gasteropods on one side, and to the carnivorous Gasteropods on the other, until both these series meet together, and form a perfect circle in the family of *Turbidæ*. It will subsequently appear that this remarkable principle of variation is not merely confined to the first great circle formed by the *Testacea*; it is abundantly evident in its primary divisions—nay, in some instances, even in its families. Among the *Cephalopoda* it is particularly strong. All writers who have mentioned the *Foraminifora*, so admirably and beautifully investigated by D'Orbigny, hesitate not to place these microscopic atoms in that order, although it contains the most perfect Mollusca in existence: and yet the organization of these beings is so very simple that, if no regard be paid to the difference of analogy and affinity, they might be placed next to the animalculæ in the class *Acrita*. The Chitons among our *Gasteropoda*, and the genus *Chelisoma* in the circle of the *Dithyra*, are further instances: both are the most simple and slightly organized of their separate groups; and both, in this respect, as well as in the shape of their bodies, are prototypes of the *Planaridæ* and *Fasciolæ*, among the parasitic *Testacea*. But the universally confessed affinities of the naked slugs to the testaceous snails brings this theory home to the personal cognisance of every naturalist. Some of these creatures are so small, gelatinous, and so little organized, that, but for their indisputable and immediate affinity with the beautiful land shells of the Helix race, no one would think of placing them in the same order, much less in the same family; and yet every zoologist sees that such is their natural situation. Hence these naked slugs become nothing more than prototypes of

the *Planariæ* and *Fasciolæ:* related, indeed, to them by *analogy*, but without any connection whatever in regard to *affinity*. The extraordinary genus *Herpa*, one of the splendid discoveries of Guilding, carries this analogical resemblance to the highest pitch; so that but for the discriminating acumen of that profound observer, we should have been tempted, without seeing the animal, to consider it was an actual type of *Planaria*, in the disguise only of a *Limax*. On these and numerous other similar facts resulting from the analysis of this class, we hesitate not to place a portion of Cuvier's intestinal worms as the most aberrant order of the testaceous Mollusca."

So much for the connection of the orders; and now you are to remark that each of these orders must have an analogical relation with its corresponding order of the vertebrate and annulose animals, above, below, and around them. Thus the Gasteropods represent, analogically, the Quadrupeds; the Dithyra, the Birds; the Nudibranchia, the Reptiles; the Parenchymata, the Amphibians; and the Cephalopoda, the Fishes: and there is really much ingenious fancy brought into play in conjuring up the correspondent resemblances—the fancy, too often, it is true, unchecked by the stubborn facts wherewith anatomy attempts to bar its flight. Thus we are taught that the Cephalopods, here made the analogues of the lowly vertebrated fishes, are higher structured than the Gasteropods, which are, nevertheless, reckoned by Mr. Swainson to be the counterparts, in their station, of the typical Quadrupeds.

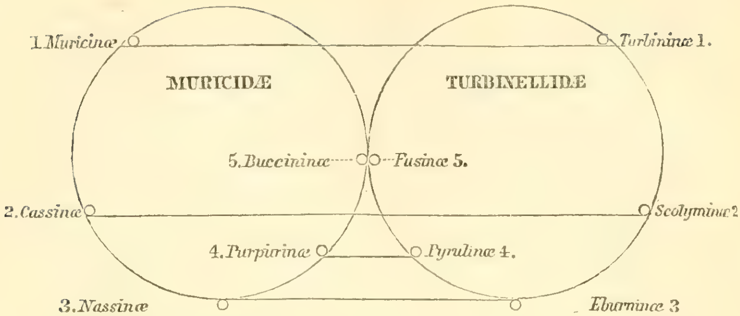
The analogies of the Mollusca with the annulose creatures is exhibited by Mr. Swainson in the following table:—

Tribes of Testacea.	*Analogical Characters.*	*Classes of the Annulosa.*
Gasteropoda.	Typical, the most highly organised; head distinct, with long antennæ or tentacula.	Ptilota.
Dithyra.	Head indistinct, confounded with the thorax, or altogether wanting; no antennæ or tentacula.	Aptera.
Nudibranchia.	Disc of the belly flattened, and often performing the office of a foot.	Annelides.
Parenchymata.	The most simple in their organisation, naked, and crawl upon their belly; no perceptible branchia.	Vermes.
Cephalopoda.	Mouth surrounded by long tentacula or arms; soft parts of the body generally protected by a shell.	Cirrhipeda.

Every order is, of course, circular, after the fashion of the primary ones. Thus, after rejecting all genera irreducible to the system (for the bed of Procrustes is oftener used than it ought to be in a well-ordered house), the Gasteropoda have five tribes, viz.: 1, the Zoophaga of Lamarck; 2, the Phytophaga of the same author: 3, the Scutibranches; 4, the Cyclobranches; and 5, the Tectibranches of Cuvier. And that these tribes are natural divisions is presumptively proved by the fact of their analogizing exactly with the orders of the Mollusca, as thus:—

Tribes of Gasteropoda.	*Analogical Characters.*	*Orders of the Testacea.*
Zoophaga.	Pre-eminently typical; mantle formed into one or two long tubular siphons.	Gasteropoda.
Phytophaga.	Siphons entirely wanting.	Dithyra.
Scutibranchia.	Animal oval, greatly depressed; the branchia, in the typical divisions, fringed, and placed on the back.	Nudibranchia.
Cyclobranchia.	Tentacula none; body broad, oval, onisciform.	Parenchymata.
Tectibranchia.	Shell, when present, protecting only a part of the body, concealed; mantle dilated into fin-like lobes.	Cephalopoda.

Each tribe has again its five "leading divisions." Those of the Zoophaga are:—1. The Muricidæ, or Murexes, having the respiratory siphon in general very much developed, and its corresponding canal at the base of the shell always straight. 2. The Turbinellidæ, or Turnip-shells, where the base of the shell is straight and lengthened, and the pillar strongly plaited. In both these, the mantle of the animal is never dilated, but is of ordinary dimensions, and drawn back into the shell with the animal. 3. The Volutidæ, or Volutes, having the mantle much developed in the typical species: the column of the shell is always marked by regular and well-defined plaits, nearly the same as in the last; but the base of the aperture is obtuse, truncate, and notched. 4. The Cypræidæ, or Cowries, whose shells are without any spire; the last whorl enveloping all the others, as in the Bullas. 5. The Strombidæ, or Wing-shells, the only division where the outer side or lip of the aperture is considerably dilated. The first two of these are the typical and sub-typical groups; the latter three forming the aberrant circle. The further analysis of the typical and sub-typical groups is exhibited in the following diagram:—



The divisions of the PHYTOPHAGA are—1, the Helicidæ; 2, the Trochidæ; 3, the Heliotidæ; 4, the Naticidæ; and 5, the Turbidæ. Their analogies with the Zoophaga are thus illustrated:—

Families of the Phytophaga.	*Analogical Characters.*	*Families of the Zoophaga.*
HELICIDÆ.	Typical.	MURICIDÆ.
TROCHIDÆ.	Sub-typical.	TURBINELLIDÆ.
HALIOTIDÆ.	Foot enormously large; tentacula very short; spire of the shell very small.	VOLUTIDÆ.
NATICIDÆ.	Shell highly polished, partly or entirely covered by the mantle.	CYPRÆIDÆ.
TURBIDÆ.	Animal carnivorous; mouth probosciform, with a respiratory siphon.	STROMBIDÆ.

The order DITHYRA is thus subdivided:—1, the MACROTRACHIA, where there are either one or two siphons; 2, the ATRACHIA, having none; 3, the TUBULIBRANCHIA, or tubular shell-fish, having an indistinct head, and an operculum to their shell; 4, the CHELIOSOMIDÆ, with a cartilaginous covering and two orifices; and 5, the BRACHIOPODA, or anomian bivalves. The whole of these have their prototypes in the Gasteropoda, as is shown in this table:—

Tribes of the Dithyra.	*Analogies.*	*Tribes of the Gasteropoda.*
MACROTRACHIA.	Animal with the mantle formed into an elongated siphon, simple or double.	ZOOPHAGA.
ATRACHIA.	Mantle free, and without a siphon.	PHYTOPHAGA.
BRACHIOPODA.	Reciprocally representing the Cephalopoda.	TECTIBRANCHIA.
CHELIOSOMIDÆ.	Body cheloniform, oval, covered with testaceous or coriaceous plates.	CYCLOBRANCHIA.
TUBULIBRANCHIA.	Animal of the gasteropod structure, furnished with an obtuse head.	SCUTIBRANCHIA.

"This table is important, were it only to prove that the usual divisions of the more typical bivalves according to the number of their muscles, whether one or two, is not a natural arrangement; because it destroys the beautiful analogy which is found to exist in the two typical tribes of the Dithyra and the Gasteropoda, and is not borne out by the details of their analysis." This is a mode of reasoning not likely to impose upon you; for the "petitio principii" will only be granted to Mr. Swainson by a devotee of his own sect,—a sect always a small one, and now on the decrease. Indeed, I am not aware that any conchologist has adopted Mr. Swainson's method, or made an attempt to complete it by a review of those orders which he left uninvestigated; and yet such a review you might undertake advantageously to task at once your ingenuity and the amount of your newly acquired knowledge. In the meantime, you will find the "Treatise on Malacology" well deserving a perusal; it is an interesting work in many respects, and is beautifully illustrated.

I now return to Cuvier, whose system, in 1829, received more applicableness to practice, and an admirable exposition, from the hand of M. Sander Rang, a distinguished officer of the French marines. The following is a synopsis of the classification as proposed by him.*

MOLLUSCA.

Class CEPHALOPODES, Cuvier.

Order I. CRYPTODIBRANCHES, Blainville.

- Fam. 1. OCTOPODES, Leach. *Genera* — Argonauta, Bellerophon, Octopus, Eledon, Loligopsis.
- Fam. 2. DECAPODES, Leach. *Genera*—Cranchia, Sepiola, Onychoteuthis, Loligo, Sepioteuthis, Sepia.

Order II. SIPHONIFERES, D'Orbigny.

- Fam. 1. SPIRULES, D'Orbigny. *Genus*—Spirula.
- Fam. 2. NAUTILACES, D'Orbigny. *Genera* — Nautilus, Lituitus, Orthoceratites.
- Fam. 3. AMMONES, Lamarck. *Genera* — Baculites, Hamites, Scaphites, Ammonites, Turrilites.
- Fam. 4. PERISTELLES, D'Orbigny. *Genera* — Ichthyosarcolites, Belemnites.

* Manuel de l'Histoire Naturelle des Mollusques et de leurs coquilles, ayant pour base de classification celle de M. le Baron Cuvier. Paris, 1829. Duod.

Order III. Foraminiferes, D'Orbigny.

Fam. 1. Stichostegues, D'Orbigny. *Genera*—Nodosaria, Frondicularia, Lingulina, Rimulina, Vaginulina, Marginulina, Planularia, Pavonia.

Fam. 2. Enallostegues, D'Orbigny. *Genera*—Bigenerina, Textularia, Valvulina, Dimorphina, Polymorphina, Virgulina, Sphæroidina.

Fam. 3. Helicostegues. *Genera*—Clavulina, Uvigerina, Bilimina, Valvulina, Rosa lina, Rotalia, Calcarina, Globigerina, Gyroidina, Truncatulina, Planulina, Operculina, Soldania, Cassidulina, Anomalina, Vertebralina, Polystomella, Dendritina, Peneroplis, Spirolina, Robulina, Cristellaria, Nonionina, Nummulina, Siderolina.

Fam. 4. Agathistegues, D'Orbigny. *Genera*—Biloculina, Spiroloculina, Triloculina, Articulina, Quinqueloculina, Adelosina.

Fam. 5. Enthomostègues, D'Orbigny. *Genera*—Amphistegina, Heterostegina, Orbiculina, Alveolina, Fabularia.

Class PTEROPODES, Cuvier.

Fam. 1. Hyales, Ferussac. *Genera*—Cymbulia, Limacina, Hyalea, Cleodora, Cuvieria, Euribia, Psyche.

Fam. 2. Clios, Ferussac. *Genera*—Clio, Pneumoderma.

Class GASTEROPODES, Cuvier.

Order I. Nucléobranches, Blainville.

Fam. 1. Firolides, Rang. *Genera*—Firola, Carinaria.

Fam. 2. Atlantides, Rang. *Genus*—Atlanta.

Order II. Nudibranches, Cuvier.

Fam. 1. Pterosomes, Rang. *Genus*—Pterosoma.

Fam. 2. Glaugues, Ferussac. *Genera*—Glaucus, Laniogerus, Briaræa, Eolidia, Tergipes.

Fam. 3. Tritoniens, Ferussac. *Genera*—Thethys, Melibe, Scyllæa, Tritonia.

Fam. 4. Les Doris, Ferussac. *Genera*—Polycera, Doris, Onchidoris.

Fam. 5. Placobranches, Rang. *Genus*—Placobranchus.

Order III. Inferobranches, Cuvier.

Fam. 1. Phyllidiens, Lamarck. *Genera*—Phyllidia, Diphyllidia.

Fam. 2. SEMI-PHYLLIDIENS, Lamarck. *Genera* — Ancyllus, Pleurobranchæa, Pleurobranchus, Umbrella, Spiricella, Siphonaria.

Order IV. TECTIBRANCHES, Cuvier.

Fam. 1. APLYSIENS, Blainville. *Genera* — Aplysia, Bursatella, Actæon.

Fam. 2. ACÈRES, Cuvier. *Genera* — Akera, Bulla, Gasteropteron, Sormetus.

Order V. PULMONES INOPERCULES, Ferussac.

Fam. 1. LIMACES, Ferussac. *Genera* — Onchis, Onchidium, Limacella, Limax, Parmacellus, Testacellus.

Fam. 2. LIMACONS, Ferussac. *Genera* — Vitrina, Helix, Vertigo, Partula.

Fam. 3. AURICULES, Ferussac. *Genera* — Carychium, Auricula, Pedipes, Scarabus.

Fam. 4. LIMNÉENS, Lamarck. *Genera* — Planorbis, Limnæa, Physa.

Order VI. PULMONES OPERCULES, Ferussac.

Fam. 1. HELICINES, Ferussac. *Genus* — Helicina.

Fam. 2. TURBICINES, Ferussac. *Genera* — Ferussina, Cyclostoma.

Order VII. PECTINIBRANCHES, Cuvier.

† *A membranous appendage to introduce the water into the branchiæ.*

Fam. 1. TURBINES, Ferussac. *Genera* — Paludina, Turritella, Proto, Vermetus, Siliquaria, Magilus, Valvata, Natica.

Fam. 2. TROCHOÏDES, Cuvier. *Genera* — Navicella, Nerita, Ampullaria, Ianthina, Litiopa, Phasianella, Trochus, Pleurotomaria, Scalaria, Melanopsis, Planaxis.

†† *A siphon to introduce the water to the branchiæ.*

Fam. 3. CÉRITES, Ferussac. *Genus* — Cerithium.

Fam. 4. POURPRÉS, Adanson. *Genera* — Buccinum, Harpa, Purpura, Concholepas, Nassa, Dolium, Cassidaria, Cassis, Cancellaria, Ricinula, Murex, Colombella, Turbinella, Pyrula, Fasciolaria, Fusus, Pleurotoma, Rostellaria.

Fam. 5. STROMBES, Ferussac. *Genus* — Strombus.

Fam. 6. CONES, Ferussac. *Genera* — Conus, Subula.

Fam. 7. ENROULÉS, Lamarck. *Genera* — Terebra, Mitra, Terebellum, Ancillaria, Oliva, Cypræa, Ovula, Volvaria, Marginella.

Fam. 8. VOLUTES, Ferussac. *Genera*—Voluta, Cymbium.

††† *Neither membranous appendage nor siphon.*

Fam. 9. SIGARETS, Ferussac. *Genera* — Coriocella, Sigaretus, Cryptostomus, Stomatella, Stomatia, Velutina.

Order VIII. SCUTIBRANCHES, Cuvier.

Fam. 1. ORMIERS, Cuvier. *Genus*—Haliotis.

Fam. 2. CABOCHONS, Ferussac. *Genera*—Calyptrea, Crepidula, Notrema, Hipponix, Capulus.

Fam. 3. PATELLOIDES, Ferussac. *Genera*—Parmophorus, Emarginula, Fissurella.

Order IX. CIRROBRANCHES, Blainville.

Fam. 1. DENTALES. *Genus*—Dentalium.

Order X. CYCLOBRANCHES, Cuvier.

Fam. 1. PATELLES, Ferussac. *Genus*—Patella.

Fam. 2. OSCABRIONS, Ferussac. *Genus*—Chiton.

Class ACEPHALES, Cuvier.

1 *Section.* ACEPHALES TESTACES, Cuvier.

Order I. BRACHIOPODES, Cuvier.

Fam. 1. LINGULES. *Genus*—Lingula.

Fam. 2. TÉRÉBRATULES. *Genera* — Terebratula, Strophonema, Thecidea, Calceola.

Fam. 3. CRANIES. *Genera*—Crania, Orbicula.

Order II. RUDISTES, Blainville.

Fam. 1. ACARDES, Ch. Des Moulins. *Genera* — Sphærulites, Hippurites.

Order III. LAMELLIBRANCHES, Blainville.

1 Division—MONOMYARIES.

Fam. 1. OSTRACÉS, Cuvier. *Genera*—Anomia, Placuna, Harpax, Ostrea, Gryphæa.

Fam. 2. PECTINIDES, Lamarck. *Genera*—Podopsis, Spondylus, Hinnites, Plicatula, Pecten, Dianchora, Pedum, Plagiostoma, Lima.

Fam. 3. MALLÉACÉS, Lamarck. *Genera*—Posidonia, Vulsella, Perna, Crenatula, Malleus, Gervilia, Inoceramus, Pulvinites, Catillus.

Fam. 4. AVICULÉS. *Genus*—Avicula.

2 Division.—DIMYAIRES.

Fam. 5. ARCACÉS, Lamarck. *Genera* — Cuculæa, Arca, Pectunculus, Nucula, Trigonia.

Fam. 6. MYTILACÉS, Cuvier. *Genera* — Mytilus, Lithodomus, Pinna.

Fam. 7. SUBMYTILACÉS, Blainville. *Genera* — Anodonta, Unio, Cardita, Cypricardium.

Fam. 8. CAMACÉS, Lamarck. *Genera* — Etheria, Chama, Diceras, Caprina, Isocardia, Tridacna, Hippopus.

Fam. 9. CONCHACÉS, Blainville. *Genera*—Iridina, Cardium, Hemicardium, Capsa, Donax, Gratelupia, Tellina, Lucina, Corbis, Amphidesma, Cyprina, Mactra, Erycina, Cyclas, Cyrena, Galathea, Crassatella, Astarte, Venus, Venerupis, Petricola, Coralliophaga, Clotho, Ungulina.

Fam. 10. PYLORIDÉS, Blainville. *Genera*—Corbula, Pandora, Thracia, Periploma, Anatina, Mya, Lutraria, Psammocola, Soletellina, Sanguinolaria, Solecurtus, Solen, Solemya, Glycimeris, Panopæa, Saxicava, Byssomia, Rhomboides, Hiatella.

Fam. 11. TUBICOLÉS, Lamarck. *Genera*—Aspergillum, Clavagella, Gastrochæna, Pholas, Jouannetia, Teredo, Fistulana, Septaria, Teredina.

2 *Section* ACEPHALES NON TESTACES, Cuvier.

Order IV. HETEROBRANCHES, Blainville.

Fam. 1. ASCIDIENS, Lamarck. *Genera* — Ascidia, Bipapillaria, Fodia, Pyura, Distoma, Botryllus, Synoicum.

Fam. 2. SALPIENS, Blainville. *Genera* — Salpa, Timoriensis, Monophorus, Phylliroe, Pyrosoma.

A sort of commentary on the leading sections of this table will lead me as far as I intend to guide you in this field.

1. CEPHALOPODA.

In 1825, M. de Haan, and in 1826, M. D'Orbigny published the results of their study of this class, more especially of its fossil constituents: and they made a large increase to our knowledge of their structure. The researches of D'Orbigny were more general and comprehensive than those of the Dutch naturalist, and M. Rang has availed himself of them only in his arrangement, which is to be considered as a literal reproduction of his countryman's method,—the families and genera standing in the same relation to each other, and under the same designations. Shortly afterwards three discoveries contributed to alter the systematic view of the class. The first was Professor Owen's Anatomy of the Nautilus pompilius, published in 1832,* whereby our almost conjectural notions of the tenants of the polythalamous shells were swept away, and certain knowledge substituted in their place. The second was the ascertainment of the simple and

* Memoir on the Pearly Nautilus, &c. By RICHARD OWEN. Lond. 1832. 4to.

acritous structure of the animals of the microscopical multilocular shells by M. Dujardin, in 1835;* and the third was the confirmation of Cuvier's opinion regarding the non-parasitism of the cephalopod found in the shell of the Argonaute. Hence, in 1836, we have, from the accomplished Professor Owen, the following improved and excellent method of the Cephalopoda:†—

Order I. Tetrabranchiata. Branchiæ four in number. The Nautilus pompilius is the type of the order.

Fam. 1. Nautilidæ. Shell external; spiral or straight; septa smooth and simple, the last chamber the largest, and containing the animal: siphon central, or marginal and internal.—*Ex.* Nautilus, Clymenes, Campulites, Lituites, Orthoceratites.

Fam. 2. Ammonitidæ. Shell external; spiral or straight; septa sinuous and with lobated margins, the last chamber the largest and lodging the animal: siphon central, or marginal and external.—*Ex.* Baculites, Hamites, Scaphites, Ammonites, Turrulites.

Order II. Dibranchiata. Branchiæ two in number.

Tribe Decapoda.

Fam. 1. Spirulidæ. Shell partly internal; cylindrical, multilocular, discoid, the whorls separated; septa transverse, concave next the outlet, and with regular intervals. Siphon marginal, and internal, uninterrupted. *Ex.* Spirula.

Fam. 2. Belemnitidæ. Shell internal, composed of an external calcareous sheath, formed by a succession of hollow cones, the exterior being the largest; of an internal horny sheath, also of a conical form; containing at its apex a chambered shell, the septa of which are concave externally, and perforated by a marginal and ventral siphon. *Ex.* Belemnites.

Fam. 3. Sepiadæ. *Animal,* body oblong, depressed, with two narrow lateral fins extending its whole length. *Shell* internal, lodged in a sac in the back part of the mantle, composed of an external calcareous apex or mucro, of a succession of calcareous laminæ with intervening spaces filled with air, and supported by columns, but not perforated by a siphon, and an internal horny layer, corresponding

* See the Annales des Sciences Naturelles for 1834 and 1835.

† Cyclopædia of Anatomy and Physiology. Part vi., May, 1836.

to the anterior horny sheath of the Belemnites. *Ex.* Sepia.

Fam. 4. TEUTHIDÆ. *Animal*, body sometimes oblong and depressed, generally elongated and cylindrical; with a pair of fins varying in their relative size and position, but generally broad, shorter than the body, and terminal. *Shell* internal, rudimental, in the form of a thin straight elongated horny lamina, encysted in the substance of the dorsal aspect of the mantle. *Ex.* * Sepioteuthis, Loligo, Onychoteuthis, Rossia, Sepiola. ** Loligopsis, Cranchia.

Tribe OCTOPODA.

Fam. 5. TESTACEA. This family embraces the genus Argonauta, and, perhaps, the fossil Bellerophon. It is defined: Body oblong, rounded; mantle adhering posteriorly to the head; first or dorsal pairs of arms, dilated and membranous at the extremity: Funnel without a valve, but articulated at its base by two ball and socket joints to the inner sides of the mantle. Branchial hearts with fleshy appendages: No internal horny or testaceous rudiments; but an external monothalamous symmetrical shell, containing, but not attached to, the body of the animal; which also deposits its eggs in the cavity of the shell.

Fam. 6. NUDA. Body generally rounded, mantle broadly continuous with the back of the head. Arms connected at the base by a broad web: first pair elongated, and gradually narrowing to a point. Funnel without an internal valve, or external joints; branchial hearts without fleshy appendages; biliary ducts without follicular appendages. Shell represented by two short rudimental styles encysted in the dorsolateral parts of the mantle. *Ex.* Octopus, Eledone.

2. PTEROPODA.

Mr. J. E. Gray has proposed to divide this small and curious class* into two orders: The first is called THECOSOMATA, because the body is enclosed in a thin shell. The head of the animals is indistinct, the mouth being placed in the centre of the two large wings, which are united into a

* M. Emile Blanchard's anatomy of the ganglia of the Pteropods confirms the view of Cuvier in making a separate class of them, in opposition to Blainville, who would mingle them with the Gasteropods.—Syst. Nerv. chez les Invertebres, 10.

funnel-shaped expansion; the gills are internal, and the creatures use their fins as oars to their boat-like shell when they swim on the calm ocean.

This order embraces four families: 1, CLEODORIDÆ, which have an elongate, or subglobose conical glassy shell; and the fins are simple without any intermediate foot-like lobe. 2, LIMACINIDÆ, distinguished from the first by its spiral discoidal shell. 3, CUVIERIDÆ, with a glassy conical cylindrical shell, which becomes truncate in its adult state: and 4, CYMBULIADÆ, in which the shell is only of a firm gelatinous substance, variable in figure, but generally somewhat resembling a slipper.

The second order, or GYMNOSOMATA, are destitute of any shell; the head is distinct, and there are two or four distinct fins on the neck, and a central foot-like appendage between their bases. The gills are external. Three families enter into the composition of the order. The PNEUMODERMIDÆ have a fusiform body, and the head is furnished with two contractile arms, armed with peduncled suckers; they have two wings, and the gills are posterior. The CYMODOCEIDÆ have two wings on each side, placed in the space that separates the body into two parts; and the CLIONIDÆ have two wings only, which are said to be covered with a vascular network, and serve the purpose of gills. They and the Limacinæ are the chief food of the whales.*

3. GASTEROPODA.

The few alterations made by M. Rang in the arrangement of the Gasteropods, are in harmony with Cuvier's principles. His Nucleobranches, corresponding pretty exactly to the Heteropods of Cuvier, are placed at the head to make the alliance of the class with the Pteropods less abrupt; but it would have been better to have removed the Pteropods from the position they occupy to a lower rank; for we now know that their structure is of lower organization, and we know, moreover, that the pectinibranchial Gasteropods leave no space between them and the Tetrabranchiate Cephalopods to be occupied by any intervening class.† The orders Pulmonés-opercules and Cirrhobranches were rejected by Cuvier, and with good reason: the former rested on characters incongruous with the system, and apparently of not more than subordinal value; and the structure of the Dentalium, the only cirrhobranchial Mollusk, seems to prove it to be a mere family

* Syn. Brit. Mus. 1842, p. 86.

† Blainville and Souleyet maintain that the Pteropods are a tribe of Gasteropods allied to Bulla and Aplysia.

group, situated between the Chiton and Patella. According to Deshayes, on whose authority the order Cirrhobranchiata solely rests, the branchiæ in Dentalium are grouped in the form of two tufts of long soft filaments with clavate extremities, one on each side of the animal's neck; but Mr. Clark appears to have proved that these organs are really salivary glands: so that the usually accepted view of the cirrho-branchiate character of Dentalium becomes untenable.*

In 1842, or earlier, Mr. J. E. Gray proposed a very material modification of Cuvier's arrangement;† and the differences between them will be made most obvious by reducing Mr. Gray's method to a tabular form. The Gasteropoda then are—

1. CTENOBRANCHIATA with the respiratory organs consisting of one or more comb-like gills placed on the inner side of the mantle, which forms an open bag in the last whorl of the shell, over the back of the neck.

Order I. ZOOPHAGA, embracing five families, viz.— 1. Strombidæ; 2. Muricidæ; 3. Buccinidæ; 4. Volutidæ; 5. Cypræadæ.

Order II. PHYTOPHAGA.

Section I. *Podophthalmi.*

Eyes placed on short pedicels at the back inner angle of the tentacula.

* Sides of the body furnished with a fringe sending out a series of tentacular filaments.

The *families* are 1. Turbinidæ; 2. Trochidæ; 3. Stomatellidæ; 4. Haliotidæ; 5. Fissurellidæ; 6. Dentaliadæ; 7. Lottiadæ.

** Sides of the body destitute of fringe and filaments. Tentacula generally elongate and slender. Shell interiorly always opake and porcellaneous.

The *families* are 1. Neritidæ; 2. Ampullariadæ; 3. Ianthinidæ; 4. Atalantidæ.

Section II. *Eriophthalmi.*

Eyes sessile, or only placed on a very small prominence at the base of the tentacula: sides simple.

* Branchiæ formed of triangular plates and not exposed: shells generally regularly spiral with a moderately sized aperture.

* Forbes and Hanley Brit. Mollusca, iii. 447. Mr. Clark's very interesting paper is in the Ann. and Mag. Nat. Hist. Ser. 2, iv. 321.

† Synopsis of the Contents of the British Museum. Lond. 1842. Duod. —Mr. Gray states that his method was first published in 1838. Proceed. Zool. Soc. No. 178, p. 129.

The *families* are 1. Naticidæ; 2. Littorinidæ; 3. Truncatellidæ; 4. Paludinidæ; 5. Velutinidæ; 6. Pyramidellidæ; 7. Tornatellidæ.

** Branchiæ formed of long filaments, and often protruded when the animal is expanded. Shell various and anomalous in form, with often a very large aperture.

The *families* are 1. Valvatidæ; 2. Vermetidæ; 3. Vanicoroidæ; 4. Capulidæ; 5. Crepidulidæ; 6. Phoridæ.

II. HETEROBRANCHIATA. Branchiæ variously formed, or respiring by means of lungs.

Order III. Pleurobranchiata. Branchiæ lamellar placed on the right side of the back, and covered with a thin mantle, which is sometimes protected by a small shell, more or less sunk within its substance.

* Branchiæ on the side of the back and covered by the mantle.

The *families* are 1. Bullidæ; 2. Aplysiadæ; and perhaps, 3. Pterotracheidæ; 4. Argonauta, and 5. Bellerophon.

** Branchiæ on the right side of the body, in the groove between the edge of the mantle and the foot.

The *families* are 1. Pleurobranchidæ; 2. Umbrellidæ.

Order IV. Gymnobranchiata. Branchiæ naked, various, placed on different parts of the back, or a series of plates placed round the edge of the mantle.

* Branchiæ placed on the back and exposed.

The *families* are 1. Doridæ; 2. Tritoniadæ; 3. Placobranchidæ.

** Branchiæ lamellar, on the edge of the under side of the mantle.

The *families* are 1. Phyllidiadæ; 2. Patellidæ; 3. Chitonidæ.

Order V. Pneumobranchiata. Respiring free air.

* The respiratory cavity closed by the edge of the mantle being attached to the back of the neck, leaving only a small hole, covered with a fleshy valve, for the entrance and escape of air. No operculum.

a. Eyes on the top of the long cylindrical tentacula.

The *families* are 1. Arionidæ; 2. Helicidæ; 3. Veronicellidæ; 4. Onchidiadæ.

b. Eyes placed at the base of the tentacula.

The *families* are 1. Auriculidæ; 2. Limnæadæ.

c. No distinct tentacula.

The *families* are 1. Amphibolidæ; 2. Siphonariadæ; 3. Gadiniadæ.

** The respiratory chamber open, viz. the front edge of the mantle is free from the back of the neck, leaving a large slit for the admission of the air into the bag. An operculum.

The *families* are 1. Cyclostomidæ; 2. Helicinidæ.

There can, I think, be only one opinion as to the great merits of this method, of which the author has given a most interesting exposition in the work referred to, one of small price and easy access. Its superiority as a whole to any previous one can scarcely be questioned; and the new views taken as to the position of several of the families in their respective orders, as well as in regard of the genera which are made to enter into the composition of the families, nothing less than the most extensive and critical knowledge of the entire class could have suggested. The method, Mr. Gray says, "is founded on the examination of the animals of all the molluscans contained in the London and Paris collections, as well as of all the drawings or engravings of the animals which I have been enabled to see, exceeding more than five thousand species, being at least one hundred times as many animals as were known when Lamarck proposed his system, and fifty times as many as were known to Cuvier when he published his system on the Animal Kingdom."* The defects of it proceed from having had the attention too exclusively directed to the exterior anatomy of the animal irrespective of the form of the shell; whence it has resulted that the Haliotidæ are found alongside of the Trochusidæ, although their relationship is really distant, as Cuvier had proved. Other, and not less prominent, instances of mis-alliance might be pointed out, but the one selected has been made more apparent and decisive of late by the researches of Milne-Edwards and Emile Blanchard; and these researches, again, have effected a revolution in the arrangement of the class, which will, probably, receive the adhesion of future naturalists.

From the more or less perfect formation of the foot, which regulates the motions and much of the economy of the animal, Milne-Edwards proposes to divide the Gasteropoda into two subclasses, viz. 1. the normal Gasteropods, embracing the Pulmones, Nudibranches, Inferobranches, Tectibranches, Pectinibranches, Scutibranches, and the Cyclobranches of Cuvier; and 2. the aberrant Gasteropods or Heteropodes of the same author.

* Proceed. Zool. Soc. Lond. No. 178, p. 132.

The normal Gasteropods, although very numerous in species, are a natural group, exhibiting in its families, however, considerable variety in the organism, which appears even in the embryo at an early period of its development. In some the larva is furnished with a turbinated shell having the aperture closed by means of a little operculum ; over the front of the head there is a large membranous veil more or less deeply divided into two lobes and garnished with a fringe of vibratile cilia, to make this veil an organ of locomotion ;* and there is nothing to be observed that can be compared to an umbilical vesicle. In others the larva is naked ; the head is not furnished with natatory veils with ciliated margins ; and there exists, upon the anterior part of the dorsal region, a kind of umbilical vesicle.

The Gasteropods that, in these first steps of their development, affect these two forms, present also considerable anatomical and physiological differences when they have come to maturity. Some are pulmonated and breathe the unmingled air ; others breathe water and are provided with gills. The first have been long separated from the branchiferous Gasteropods ; but the close affinity which binds the latter together has not been sufficiently appreciated, nor indicated in our systems ; for in all of them these mollusks are scattered throughout in a variable number of ordinal divisions, and no systematist has hitherto perceived that they constitute but one, although a large, group. Yet it is certain that, in their embryotic condition, the different families so much resemble each other that it would be difficult to distinguish generically the larvæ of the Eolides, or of the Aplysiæ, from the larvæ of the Buccina and of the Vermetus.

The normal branchiferous Gasteropods only differ from each other when they have advanced towards their ultimate forms ; but the peculiar character of the heart, whose first existence is later here in life than in animals of higher organization, separates them into two natural groups, which ought, according to Milne-Edwards, to take the rank of Orders.

In one of these, named Opistobranches, the blood is brought to the heart in a current directed more or less obliquely from behind forwards, and the auricle is usually placed in rear of the ventricle ; the respiration is effectuated by the aid of arborescent or fasciculated branchiæ, which are not enclosed in an appropriated cavity, but are more or less exposed uncovered on the back or upon the sides, towards

* See Reid in Ann. and Mag. N. Hist. xvii. 382.

the hinder part of the body; the cervical region is always naked; the animals are hermaphrodite; and the shell, well developed on the larva, becomes rudimentary, or entirely disappears in the adult.

This order is constituted of Gasteropods, distributed in three of Cuvier's orders, viz. his Nudibranches, Inferobranches, and Tectibranches. In the classification of Lamarck we find them united together in the first section of Gasteropods; but they are mixed up with the Patellæ and the Chitons, whose structure is very alien. M. de Blainville again scattered them throughout four orders, which have no nigh affinity to each other; and some are widely sundered from their relations by the introduction of the Pteropods between the Aplysiæ and the Eolides. The Opistobranches form, however, a very natural group; and the characters which combine them together, as well as those which separate them from other Gasteropods, seem to justify their elevation to an ordinal rank in their class.

In the second division of the branchiferous Gasteropods, the abdominal portion of the body does not become rudimentary as in the Opistobranches, but is developed, on the contrary, in due proportion to the cephalic and pedal portions; and it is, throughout life, protected by a shell sufficiently large to allow the body to be drawn within its cavity. The cloak is always directed forwards, and forms, above the cervical region, a vaulted chamber of variable capacity where the excretory vents open externally, and in which the branchiæ are lodged. These respiratory organs are composed of simple lamellæ, laid parallel to each other, inserted along a vascular support, and affecting a pectinated or comblike figure. In general they are situated in front of the heart, and even when they are prolonged to the posterior part of the body, the branchio-cardiac vessels trend from before backwards, so that the blood comes to the heart in a current the reverse of that in the Opistobranches. Lastly, every species has its male and female individuals.

In the classification of Cuvier the Gasteropods that possess this assemblage of anatomical and physiological characters are disseminated in the orders Pectinibranches, Tubulibranches, Scutibranches, and Cyclobranches. Lamarck has arranged a part of them amongst his Gasteropods, and another part amongst his Trachelipods, where they mix but do not combine with the Pulmonata. M. de Blainville forms with them the first and the third of his subclasses of Paracephalophores, and intercalates between these two groups all the other Gasteropods. Milne-Edwards justly prefers to re-

unite them in one and the same order, to which he gives the name of Prosobranches.

As to the Chitons, it is difficult to say where they can be placed most naturally in the system. Cuvier and Lamarck have concluded them to be affined to the Patellæ,—a decision in which concologists in general have acquiesced; but Blainville, being of opinion that they are not mollusks forms a class of them amongst annulose animals. To justify this view, he reminds us of the peculiar disposition of the valves of the Chitonidæ, which prompts a comparison with the segmented character of the Annelides; and of the position of the vent opposite to the mouth, which is likewise an annulose and not a molluscan structure. Milne-Edwards adds that the reproductive organs, while they differ essentially from those of Gasteropods, resemble those that are found in the Annelides. In the Gasteropods these organs are always unpaired and asymmetrical as well interiorly as in the position of their external orifices; but in the Chitons they are arranged alike on each side of the mesial line, with a couple of orifices similar to those of the Crustacea. The disposition of the circulating apparatus tends equally to alienate the Chitons from the Gasteropods, and to approximate them to the articulated animals, for the heart simulates a dorsal vessel, and has a structure very different from that of any normal Gasteropod. In fact, every thing in the organisation of the Chitonidæ appears to indicate a tendency to a bilateral distribution of the organs regulated by a straight line; while in the Gasteropoda the body as a whole, and in its parts, seems to have been modelled on a curved line. Thus the opinion of Blainville would appear to be more correct than that of Cuvier, as to the rank of the Chitons; but to solve the question it is first necessary to know the phases of these animals in their development: for it is their embryotic condition that can alone inform us if they are descendants from the Mollusca which have received some features of the annelidan race; or if they rather descend from the Annelides and ape only in part the habit of the Mollusca. Yet, however this question may be answered, it seems impossible to retain the Chitons any longer amongst normal Gasteropods: and were it decided to attach them to the Mollusca, it would be necessary to form with them an order apart, or rather to detach them as a small satellitious group, pendant from the typical body, without just being a constituent portion of it. Mac Leay would call it an *osculant* group; but Milne-Edwards, more fanciful than he, would liken it to a satellite that occupies a thinly-studded field in space, removed far away from the closely

stellar constellations that crowd the glorious vault of heaven. —Guided by these views, Milne-Edwards classifies the Gasteropods thus:—

Class—GASTEROPODA.

Cephalous Mollusca, with a fleshy foot for locomotion, formed by a posterior lobe of the head; the organs of generation unpaired and unsymmetrical, and the entire organism modelled on a spiral line, either in the larva state only or throughout life.

Typical Group, or Subclass I. NORMAL GASTEROPODS.

Foot fleshy, flattened, and very large; abdomen well developed, &c.

1 Section. Pulmonated Gasteropods.

Larva with a naked head, &c.; vessels of the lesser circulation reticulated; androgynous.

2 Section. Branchiferous Gasteropods.

Larva with cephalic swimmers, &c.; vessels of the lesser circulation fasciculated.

Order I. Opistobranchia. Cervical region naked, &c.

Order II. Prosobranchia. Cervical region surmounted with a vaulted pallial cavity, &c.

Aberrant Group, or Sub-class II.—SWIMMING GASTEROPODS, OR HETEROPODS.

Foot fleshy, vertical; abdomen rudimentary, &c.

Satellitious group of Gasteropods *pendulous from the Prosobranchia.*

Family, CHITONIDÆ. Cephalous Mollusca? with a fleshy foot; the body subannular; generative organs paired and symmetrical: a medial dorsal vessel, &c.*

These great reforms of Milne-Edwards derive support from the delicate and elaborate dissections of his young friend, M. Emile Blanchard. This adroit and gifted naturalist, in addition to the characters above assigned to the Opistobranches, tells us that the cephalic ganglia of the nervous system have a closer centralisation than they have in other Gasteropods,—a fact which had been previously made known to us, in many Nudibranches, by Mr. Hancock and Dr. Emble-

* Annales des Sciences Naturelles, ix. (1848), p. 102—112. It appears the classification was first published in August, 1846.—Mr. J. E. Gray has defined the genera of Chitonidæ in the Ann. and Mag. N. Hist. xx. 66.

ton.* Hence M. Blanchard infers that to this sub-class must be assigned the first or highest rank amongst the gasteropod mollusca—a conclusion to which Milne-Edwards had also come from embryogenic considerations. You may reasonably falter to follow them in these views when you call to recollection the many affinities that bind the pectinibranchial Zoophaga with the tetrabranchiate Cephalopods; and there are structural peculiarities in the circulating system, and in the form of the gills, that would lead us to believe that the Opistobranches cannot, in a natural system, be far dissociated from the Bivalves. To assert that the centralisation of the nervous system disproves their right to this lower position is to assume the question at issue, for the importance justly attachable to that character must depend on its being correlative with an equal elevation in other systems, and on its coincidence with the animal's general economy and habits.†

Of the Mollusca which enter into the composition of the Opistobranches, none have attracted greater attention than the Nudibranches. Linnæus knew imperfectly six or seven species only of this order; Müller added several from the shores of Denmark to the number; and Colonel Montagu augmented the catalogue with some English supplies. His example was followed by Dr. Leach in England, by Professor Jameson in Scotland, and by Dr. Fleming in Zetland; but Müller had more ardent followers in Nordmann, Sars, Löven and Kölicker, who began to mark their progress by discoveries in the structure and development of the animals. Cuvier, however, had long before worked the same field, and with his usual superiority and success; for his anatomies

* "On taking a review of the nervous system of Eolis, we are at once struck with the high grade of development, and with the symmetrical arrangement that obtains in it; the heterogangliate character applicable to many gasteropodous mollusks being, so far as our researches have led us, inapplicable to this more elevated being. The nervous centres are closely concentrated around the œsophagus, and there exists a sufficient correspondence between them and the same organs in the Cephalopoda to enable us confidently to compare them; indeed we have every reason to think that we recognise in them the homologues of the principal masses of the nervous centres of the vertebrata."—Ann. and Mag. N. Hist. Ser. 2. iii. 191.

† In relation to the position of the Chitonidæ M. Emile Blanchard has made a similar remark: "Mais les caractères les plus généraux n'étant presque jamais absolus, on peut se méprendre facilement, si l'on s'en tient à la consideration d'un seul fait, et non pas à tout l'ensemble de l'organisation."—Ann. des Sc. Nat. ix. (1848), 184.—Blanchard's very interesting papers on this order are contained in this and in the eleventh volumes. They are not yet completed. From the disposition of their nervous ganglia, M. Blanchard restores the Chitonidæ to the place usually assigned them near the Patella and Haliotis. Du. Syst. Nerv. chez les Invertebres, p. 9.

of the genera that came under his investigation are models for posterity to imitate, perhaps not to excel. Yet his countrymen have rivalled him; and from the admirable essays of M. de Quatrefages, Souleyet, Milne-Edwards, and Emile Blanchard, we might learn nearly all that is yet known of the order in an anatomical and physiological view.

M. de Quatrefages, in 1844, proposed to detach from the Nudibranches a considerable tribe, and with it to establish a new order amongst the Gasteropoda, distinguished by the inferiority or degradation of their structure. In the Eolidina he asserted that the circulatory apparatus was reduced to a heart and arterial vessels only, the veins having disappeared, and with them the respiratory organs. These were replaced by an intestinal tube which not merely separated from the food a chyle fit to enrich anew the impoverished blood, but further acted on it and prepared it for assimilation with the body, performing in fact the duty of the respiratory function. In the Zephyrina, in Acteon and Acteonina, the heart, which, in the Eolidina, fulfilled no other function than as an agent of mixture—"Ne remplissait plus que les fonctions d'un agent de mélange,"—disappears, and with it the entire circulating system. The alimentary tube, however, now becomes even more ramose than it is in the Eolidina, and we can detect movements in it which remind us of the pulsations of a heart. The function of respiration seems also to be entirely devolved on other structures, more especially on the skin; and the purification of the vital fluid is no longer localized in the dorsal filaments. In the Amphorina we see the intestinal ramifications again diminish in number while they increase in size, a modification of the structure which imposes on the skin an increasing share in the respiratory process; but as there still exist exterior appendages into which no intestine penetrates, so whatever may be the importance of the integuments in respiration, the function is not effected by them unassisted. But in the genus Pelta, and in the Chalides, every exterior appendage has disappeared; the intestine has seemingly become concentrated into one or two great pouches, which probably act with feebleness, and secondarily only in respiration; and the skin alone has devolved upon it the duty of that important office.

From this transference of the function by which all animated beings breathe and live, from the gills to the intestinal canal and to the skin, and which is accompanied with other modifications of the organization irreconcilable with the usual character of their class, M. de Quatrefages has proposed to remove the Eolidina, and the allied genera, to a

distinct and peculiar order to be called PHLEBENTERATA. This order he divided into families as follows :—

PHLEBENTERATA.

Gasteropod Mollusca with an imperfect circulation or none, and without respiratory organs properly so called.

Fam. 1. ENTEROBRANCHIATA. Intestine branched; the branches prolonged into the exterior appendages.

Tribe 1. *Enterobranchiata proprement dits.* Appendages isolated, more or less numerous. The genera are:

Eolida,	Calliopea,
Eolidina	Casolina ?
Zephyrina,	Glaucus ?
Amphorina,	Etc.

Tribe 2. *Ent. remibranchiata.* Appendages united into the figure of a fin. The genera are:

Acteon,	Placobranchus ?
Acteonina,	Etc.

Fam. II. DERMOBRANCHIATA. Intestine very simple, in the form of a few pouches; no exterior appendages. The genera are:

Pelta.	Chalidis.*

Although founded on other considerations, this order coincides in most respects with De Blainville's Polybranches; and the tribe of normal Enterobranchiata is exactly coequal with his family "Polybranches tetraceres." The Phlebenterata have, according to M. de Quatrefages, a relationship with the radiated animals on the one side, and with the Annelides on the other; and altogether his observations would have been eagerly impressed by Mr. Swainson into the proof of his view of the inferiority of the Nudibranches in the class, and of their osculant tendency to his Molluscan Planariæ. Unfortunately, however, scarcely were M. de Quatrefages' views made public before they were questioned and repudiated. Souleyet at once pronounced, with a too firm decision, that the anatomy on which the foundation of the order rested was erroneous; and his decision received an immediate answer in the affirmative from the most competent

* Sur les Mollusques Gastéropodes Phlébentérés in Ann. des Sc. Nat. (1844), i. p. 129—179.

judges in this country—from Alder, Hancock,* Embleton, and Allman. And, indeed, M. de Quatrefages, continuing his studies, had himself partially detected the errors that had misled him; so that in the beginning of the year 1845, he admitted the order could not be maintained, but must relapse into that from which he had attempted to dismember it. This change of view was made, he says, partly from personal observation, but principally induced by the discoveries of Milne-Edwards and Valenciennes. "In fact," he adds, "the imperfect condition of the circulatory apparatus, which I had considered as a symptom of organic degradation peculiar to the Phlebenteres, being found in an entire section or branch of the Mollusca, the relative importance I had attributed to it disappears. Moreover, I had foreseen that, in reference to their respiratory organs, forms intermediate to the Phlebenteres and the normal Nudibranches would be found. The characters which, therefore, rested on such considerations are not sufficient to establish an order; and, accordingly, I am brought to reduce the Eolides and allied genera to the rank of a family." This family M. de Quatrefages divides as before, and as we have already explained, merely altering the family denominations into that of Tribes, thus, 1, "Dorsibranches proprement dits;" 2, "Entérobranches Rémibranches;" and 3, "Dermobranches."†

Also, in 1844, but subsequently to the publication of M. de Quatrefages' earliest opinions, which he successfully controverted, Professor Allman proposed a classification of the Nudibranches founded on the belief that the ramified apparatus connected with the stomach in the Eolididæ "is truly a hepatic system, and affords an interesting example of the reduction of a gland to one of its simplest conditions."‡

* "This order we have already objected to, both on account of our opinion of the incorrectness of the theory which the name involves, and because it breaks up the order Nudibranchiata, which appears to us to be a natural group, well-distinguished by their external characters, and, though somewhat different in their internal anatomy, showing modifications, in that respect, so gradual that it is scarcely possible to draw a line of distinction which would separate them even into families."—Ann. and Mag. N. Hist. Ser. 2. i. 404.; and also iii. 197.

† The characters of these tribes M. de Quatrefages has fully described in a "Résumé des Observations faites en 1844 sur les Gastéropodes Phlébentérés," contained in Ann. des Sc. Nat. (1848), x. 121—143.

‡ "We have in these gastric ramifications one or more offsets from the lining membrane of the alimentary canal greatly extended and terminating in *culs-de-sac*, where doubtless resides the function of elaborating the biliary secretion. We have just such an appearance as a careful preparation of glandular structure would present with all its component ducts and terminal *culs-de-sac* accurately disentangled; we have in fact in the Phlebenteric

This view of the function of the organ was taken by Souleyet, and is now acquiesced in by all comparative anatomists, so that it affords an unexceptionable basis for divisions of a secondary rank, provided it is accompanied with "outward observances" that may disclose the secret structure to the zoologist, who rightfully demands that his index to the beings he searches out shall be made patent to his senses without calling to their aid the knife of the anatomist. Internal structures unrevealed by external marks, are not admissible in classifications; but in the present case there is no room for cavil. Professor Allman has exhibited his views in the following neat table :—

Order.	*Section.*	*Family.*	*Genus.*
NUDIBRANCHIATA.	Liver compact.	Branchiæ in the mesial line, placed in a circle more or less complete around the anus. DORIDIDÆ.	Doris, Polycera, &c.
		Branchiæ arranged along the sides, or scattered. TRITONIADÆ.	Tritonia, Scyllæa, Thetis.
	Liver disintegrated.	Branchiæ papillose, or branched, or muricated. EOLIDIDÆ.	Eolis, Alderia, Dendronotus, Glaucus, &c.
		Branchiæ foliaceous. ACTÆONIDÆ.	Actæon, Placobranchus.*

The naturalists who have done most, however, to make us acquainted with the beautiful constituents of this order, are Messrs. Alder and Hancock. Their "Monograph of the British Nudibranchiate Mollusca," in scientific and artistical merit, may, without a blush, take its place beside the very best works in Zoology; and you will find the genera and species illustrated therein in the most satisfactory and pleasing manner. For the details that more immediately relate to the anatomy and physiology of the animals, you must resort to the essays of these authors in the annals of Natural History, drawn up in part with the assistance of Dr. Embleton. Now, Messrs. Alder and Hancock, so conversant with the subject, reject, as utterly untenable, the order Phlebenterata of M. de Quatrefages; but with the Dermobranchiata of the French naturalist, they propose to establish a new order in the class, under the conviction that these animals

system of M. de Quatrefages nothing more or less than an unraveled liver."
—ALLMAN in Ann. and Mag. N. Hist. xvi. 156.

* Ann. and Mag. N. Hist. xvi. 161.

cannot with propriety be referred to the Nudibranches,—an order so remarkable for the beauty and variety of the branchial appendages with which the species are adorned. "The mollusks now under consideration are, on the contrary, distinguished by the extreme simplicity of external form, and by the absence of any specialized breathing organs. It would, therefore, be more in conformity with the views on which the existing orders of Gasteropoda were established by Cuvier, to consider this group as forming a separate order, characterised by the absence of specialized branchiæ; and as the function of respiration is entirely performed by the skin, we propose to call this order PELLIBRANCHIATA." It includes the genera Elysia or Actæon, Limapontia or Chalidis, Acteonina, and Cenia: and it is allied both to the Nudibranches and Inferobranches, by genera which may be deemed almost inosculating. You must refer to the original essay for the anatomical peculiarities that distinguish the order.*

Class ACEPHALA.

It is now agreed that the Heterobranches † or Tunicata ought to be removed from this to form a separate class; but there is not yet such an unanimity amongst conchologists as to the rank of the Brachiopoda. Cuvier considered them entitled to a classical rank from the structure of their breathing organs and the possession of their curiously ciliated arms; but Professor Owen regards them as rather an order in their class. "In all essential points," he says, "the Brachiopoda closely correspond with the acephalous Mollusca, and I consider them as being intermediate to the Lamellibranchiata and Tunicate orders; not, however, possessing, so far as they are at present known, distinctive characters of sufficient importance to justify their being regarded as a distinct class of Mollusks, but forming a separate group of equal value with the Lamellibranchiata." ‡ Deshayes, a name of great authority in this point, has adopted this conclusion; and he gives us his views in a table which, it seems to me, is well worth transcribing in this place.

CONCHIFERA.

First sub-Class. BRACHIOPODA, or POLYMYARIA.	1st sub-Order: Valves articulated.
	2nd sub-Order: Valves free.

* On a proposed new order of Gasteropodous Mollusca, by Joshua Alder and Albany Hancock in Ann. and Mag. N. Hist. Ser. 2. i. 401, &c.

† "A name without one single quality to recommend it."—MACLEAY.

‡ Zool. Trans. Lond. i. 159.

Second sub-Class. DIMYARIA.	Order 1st. The lobes of the mantle more or less united.	1st sub-Order: Shell regular.
		2nd sub-Order: Shell irregular.
	Order 2nd. The lobes of the mantle disjoined.	1st sub-Order: Shell regular.
		2nd sub-Order: Shell irregular.
Third sub-Class. MONOMYARIA.	Order 1st: a foot.	
	Order 2nd: no foot.	

BRACHIOPODA.

* *Valves articulated.*

Family 1. PRODUCTIDÆ. No tendinous ligament. Productus.

2. TEREBRATULIDÆ. A tendinous ligament. Terebratula.

3. THECIDEIDÆ. Shell adherent. Thecidea.

** *Valves free.*

4. LINGULIDÆ. A long tendinous pedicle fixed to the beaks. Lingula.

5. ORBICULIDÆ. Pedicle short, by the middle of the lower valve. Orbicula.

6. CRANIADÆ. Shell adherent without ligament. Calceola, Crania.†

DIMYARIA.

Order I.

* *Shell regular.*

7. TUBICOLIDÆ. Shell incrusted in whole, in part, or free in a tube which is either free or enclosed. Aspergillum, Clavagella, Fistularia.

8. PHOLADARIA. Shell free or within a tube, without ligament; with apophyses under the beak. Septaria, Teredo, Teredina, Pholas.

9. SOLENACEA. Shell gaping at the ends; ligament external; hinge simple or with one or two hooked teeth. Solemya, Glycimera, Pholadomya, Solen, Panopæa.

10. MYARIÆ. Shell inequivalve; ligament internal

† Mr. J. E. Gray has recently published a very elaborate classification of the Brachiopoda in the Ann. and Mag. N. Hist. Ser. 2. ii. 435.

upon a perpendicular tooth. Mya, Corbula, Pandora.

11. Ostéodesmes. Shell inequivalve; ligament internal; a free ossicle at the hinge. Osteodesma, Periploma, Anatina, Thracia.
12. Mactracea. Shell equivalve, closed or slightly gaping; ligament internal with or without an external ligament. Lutraria, Mactra, Mesodesma, Crassatella, Erycina, Amphidesma.
13. Petricolidæ. Shell free or boring, not enclosed in a tube, gaping, scarcely regular, ligament external. Saxicava, Petricola, Venerupis, Hyatella, Byssomia.
14. Tellinididæ. Shell free, regular: two cardinal teeth at most in each valve, sometimes lateral teeth; ligament external, on the lesser side of the shell. Sanguinolaria, Psammobia, Tellina, Donax.
15. Lucinidæ. Shell free, regular, closed; ligament external or subinternal; hinge variable; muscular impressions very large. Corbis, Lucina, Ungulina.
16. Cycladæ. Shell fluviatile; hinge simple or with lateral teeth, or with lateral and hinge teeth; ligament external. Iridina, Cyclas, Cyrena, Galathea.
17. Conchæ. Shell free, regular, closed; cardinal teeth from two to four, sometimes a single lateral tooth; ligament short, external. Cyprina, Venus, Astarte.
18. Cardiacea. Shell regular; cardinal teeth irregular, one or two lateral teeth; ligament external. Cypricardium, Isocardium, Cardium.
19. Tridacnadæ. Shell regular, truncate, sometimes gaping on one side; ligament external. Tridacna, Hippopus.

** *Shell irregular.*

20. Camacea. Shell irregular, adherent, inequivalve; a large hinge tooth. Chama, Diceras.

Order II.

* *Shell regular.*

21. Nayades. Shell regular, fluviatile, nacred; hinge without teeth or articulation; ligament external. Unio.
22. Cardites. Shell regular: one or two oblique hinge teeth. Cardita.

23. TRIGONACEA. Shell regular; hinge teeth lamellar, grooved transversely. Trigonia.
24. ARCACEA. Shell close, or gaping inferiorly; hinge multidenticulate, straight or curved, or angular. Nucula, Pectunculus, Arca, Cuculæa.
25. MYTILACEA. Shell regular, fixed by a byssus; hinge simple, edentulous or subdentate; ligament marginal subinternal. Mytilus, Pinna, Avicula.

* * *Shell irregular.*

26. ETHERIDÆ. Shell irregular, adherent; hinge edentulous; ligament in a gutter of the beaks. Etheria.
27. RUDISTES. Shell irregular, adherent; upper valve operculiform, two prominent muscular impressions in the upper valve; ligament internal. Spherulites, Hippurites, Caprina.

MONOMYARIA.

Order I.

28. MALLEACEA. Shell free, subinequivalve, with a simple or compound ligament, subinternal in one or several grooves or crenulations. Crenatula, Perna, Inoceramus, Catillus, Gervilia, Malleus, Vulsella.
29. MULLERIA. Shell adherent; hinge edentulous; ligament external. Mulleria.
30. PECTINIDES. Shell free or adherent, auricled; hinge straight; ligament internal or semi-internal. Lima, Plagiostoma, Pecten, Hinnites, Plicatula, Spondylus.

Order II.

31. OSTRACEA. Shell irregular, foliated, free or adherent; ligament internal or semi-internal. Placuna, Anomia, Ostrea.†

Class—TUNICATA.

I can scarcely consider the alterations which have been made in the classification of Savigny as improvements upon it. The rank of the Tunicata must be granted to be the

† Trait. Element. i. 212. This classification was proposed in 1830. See also Deshayes' article "Conchifera" in Cyclop. Anat. and Physiology, i. 695.

lowest in their sub-kingdom. Lamarck and Milne-Edwards go so far, indeed, as to maintain, that they have a nearer relationship to the Polypes than to the Mollusca; and we may safely consider them to be an "osculent" group with Macleay, connecting the Mollusca with the Ascidian Zoophytes. To use Mr. Macleay's words,—"The Tunicata, then, are animals which connect the *Acrita*, or lowest primary division of the animal kingdom with the *Mollusca*. From the Mollusca, however, they differ in having an external covering, consisting of an envelope distinctly organised and provided with two apertures, of which one is branchial, the other anal. They also differ from the Mollusca as well in their mantle forming an internal tunic corresponding to the outer covering or test, and provided, like it, with two openings, as in having branchiæ which occupy all, or at least part of the membranaceous cavity formed by the internal sides of the mantle. From the *Acrita* they differ in having distinct nervous and generative systems, while their intestinal canal is provided with two openings, both internal."*

This osculent group Mr. Macleay divides as follows, in a rather futile attempt to make the arrangement square with his system of quinary circles:—

TUNICATA.

Aberrant Group?	*Families.*	*Animals.*	*Generic Types.*
I. TETHYA. Or such Tunicata as have their mantle adhering to the envelope or test only at their orifices;—their branchiæ regular, constituting the sides of the respiratory cavity; and their branchial orifice surrounded by a membranaceous ring, which in general is supplied with tentacula, as in Polypes.	1. ASCIDIDÆ. *Tethyes simples,* Sav.	Simple and fixed, having their orifices externally irregular.	ASCIDIA.
	2. BOTRYLLIDÆ. *Teth. composées,* Sav.	Compound and fixed, having their orifices externally regular............	POLYCLINUM.
	3. LUCIDÆ. *Lucies,* Sav.	Compound and floating having their branchial cavity open at the two extremities.	PYROSOMA.

* Linnæan Transactions (1824) xiv. 531.

Normal Group? THALIDA. Or such Tunicata as have their mantle adhering everywhere to the envelope; their branchiæ irregular, consisting of two foliated processes attached to the sides of the thorax; and their branchial orifice merely provided with a valvule.	4. BIFORIDÆ.	Aggregated in their young state, and floating	SALPA.
	5. * * * * *	....	*****

Milne-Edwards, in a work* inferior to none of the many excellent ones with which he has enriched zoology, has proposed a new tribe or order in the class constituted of some recently discovered genera, — named Clavelina and Perophora;—because each species consists of several individuals that pullulate from a common creeping tubular root, by which they are associated together organically, and so intimately that there is even a circulation established between the different individuals of the same group. This section Milne-Edwards calls the *social*,—ASCIDIES SOCIALES,—and it has been admitted by Professor Forbes. I think that the claim to this distinction cannot be allowed. The character on which it is asserted is one of secondary importance, as seems to me proved by the fact that the gap which would separate them from the simple Ascidians is greatly narrower, and less evident, than that which would separate the social from the compound Ascidians. In habit and structure, the social do not differ in any way from the simple kinds, but the social do differ very much in both particulars from the compound kinds. Hence, I think that they ought to be reckoned merely as a family in the tribe of Ascidiadæ.

Professors Forbes and Goodsir have proposed (1841) the establishment of another tribe under the name of PELONIADÆ, with a better reason, for there is a difference in habit and economy which justifies the conclusion that would be drawn from the anatomical structure. The Peloniadæ are simple Tunicata, but they are free, and have a habit that might seduce us to look for their relations among the worm-

* Observations sur les Ascidies composées des Côtes de la Manche. Paris, 1844. 4to.

like members of the radiated division of animals. "Whilst in many of their characters they approach the true Ascidians, especially the unattached species of the genus Cynthia, in others they indicate a relationship with the cirrhograde Echinodermata. They present the remarkable positive anatomical character of a union of mantle with test; so that there can be little question of their right to be regarded as members of a distinct family of Tunicata." *

And now I bid you farewell. I have felt, as I proceeded, a growing conviction of my incompetency for the task I had too willingly undertaken; but as you have followed, with patient steps, the tedious way, so I may flatter myself you are now fitted to pursue the future course unassisted. The last two letters have wearied you, and yet there was a purpose in this strain upon your attention, for, when nicely examined, you will find that the tabular views of the systems I have given you, with more or less minuteness of detail, not only mark the successive stages in the history of our subject, but introduce you to its masters, and familiarize you with the names of the principal divisions of the Mollusca, and with their leading characters. This, I have thought, was to be best done by oft repetition under different phases; and without this familiar knowledge you cannot enter, with any pleasure, on the perusal and use of the books that must aid you onwards, and enable you to correct and supply what is here erroneous or amiss.

Be careful, in conclusion, to ride your hobby leisurely and at a pleasurable pace. It is neither for you nor me to devote our time to natural history:—it is to be your recreation. "Every man must and will have some relief from his more severe pursuits," is an axiom I borrow from a wise and good man; and you do well to seek that relief in a study that calls at one and the same time the head and heart into healthful exercise. There is enough in Conchology itself and its collateral bearings, to put the mental faculties on the stretch; and the objects on which you are to work, in their careful observation and research, cannot fail to give birth to emotions and affections and impressions of a good and cheerful kind. They are the creations of Omniscience; and there is no evil there;—nay, you may safely look upon the species your study brings under your notice as so many moral emblems to be unriddled by your skill.

"When I consider Thy heavens, the work of Thy fingers, the moon and the stars, which Thou hast ordained; What is

* Forbes and Hanley's Brit. Mollusca, i. 42.

man, that Thou art mindful of him? and the son of man, that Thou visitest him? For Thou hast made him a little lower than the angels, and hast crowned him with glory and honour. Thou madest him to have dominion over the works of Thy hands; Thou hast put all things under his feet: All sheep and oxen, yea, and the beasts of the field; The fowl of the air, and the fish of the sea, and whatsoever passeth through the paths of the seas. O Lord our Lord, how excellent is Thy name in all the earth!"

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THE END.

LONDON:
Printed by S. & J. BENTLEY and HENRY FLEY,
Bangor House, Shoe Lane.

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